THE PRODUCTION ENGINEER

JANUARY 1961

THE PRODUCTION ENGINEER

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CONTENTS

The 1960 *Sir Alfred Herbert Paper*
"THE DOCTOR IN INDUSTRY — FACTORY MEDICAL SERVICES"
by Ronald E. Lane, C.B.E., M.D.(Lond.), M.Sc.(Manchester), F.R.C.P., F.R.S.H.(Hon.), D.I.H.(Hon.) 1

Report and Discussion 8

"COMPUTERS AND PRODUCTION"
An Interim Report by D. E. Greene, A.M.I.Prod.E., A.M.B.I.M 19

"THE PRODUCTION AND PERFORMANCE OF METROLOGICAL DIFFRACTION GRATINGS"
by V. W. Stanley, B.Sc., and R. G. N. Hall, A.M.I.Mech.E. 38

Joint Discussion 44

"QUALITY AND ITS RELATIONSHIP TO THE DESIGN FUNCTION" by I. R. Smith, M.I.Prod.E. 50

CORRESPONDENCE 51

THE ANNUAL DINNER, 1960, AND PRESENTATION OF ANNUAL AWARDS 52

REPORT OF THE MEETING OF COUNCIL, 27th October, 1960 56

ELECTIONS AND TRANSFERS 58

INSTITUTION NOTES 60

DIARY FOR 1961 61

NEWS OF MEMBERS 63

NEW BRITISH STANDARDS 64

NOTICE OF ANNUAL GENERAL MEETING, 1961 65

MINUTES OF ANNUAL GENERAL MEETING, 28th January, 1960 65

REPORT ON ELECTION OF MEMBERS TO COUNCIL 66

REPORT OF COUNCIL, 1st July, 1959 - 30th June, 1960 67

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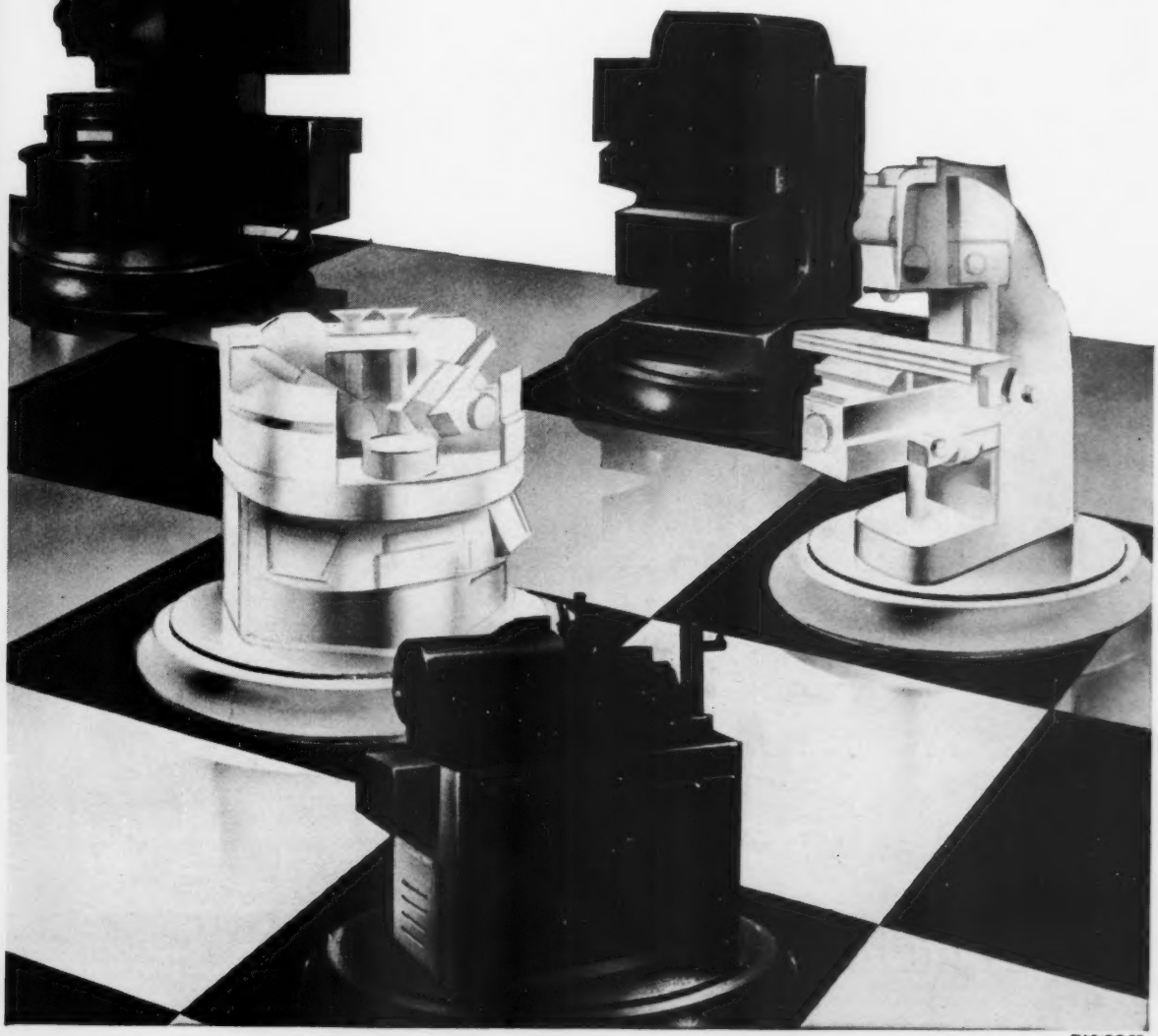

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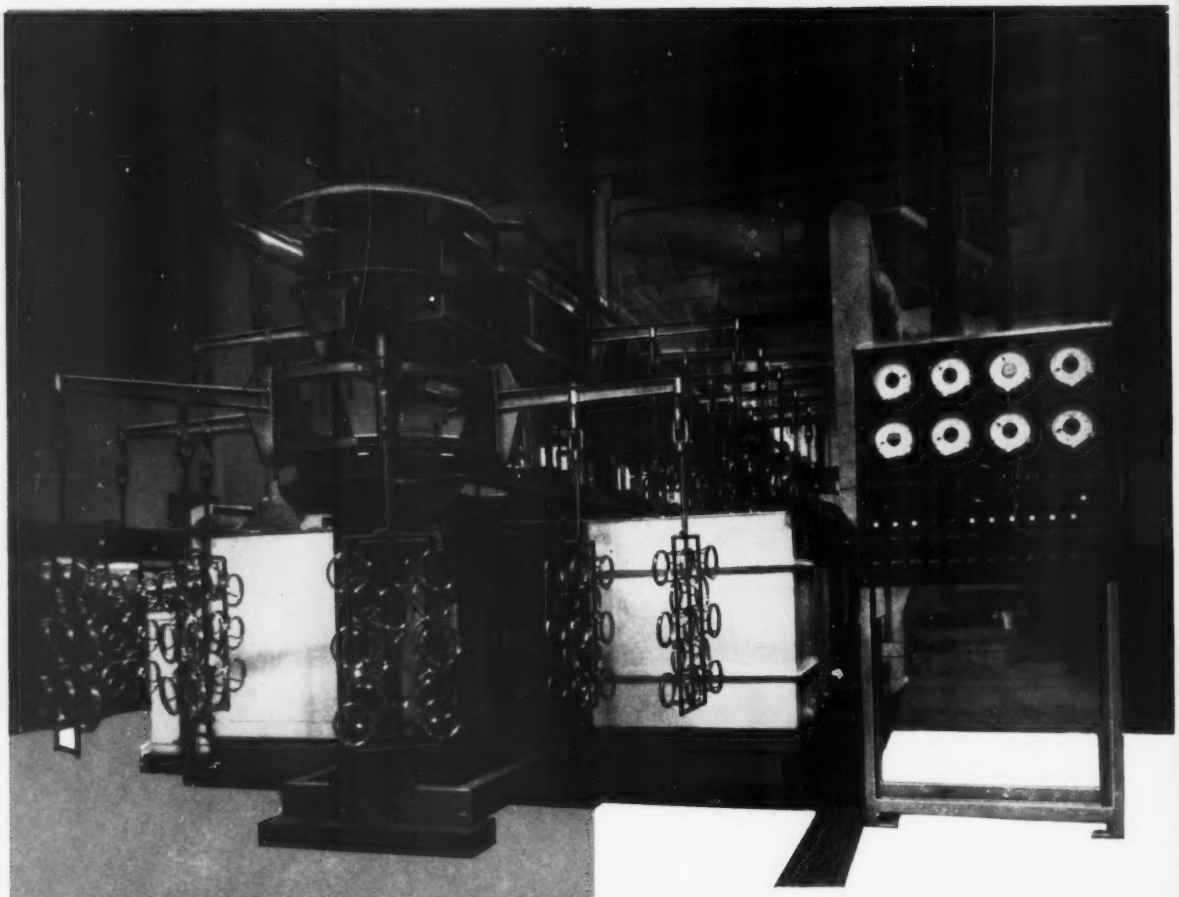

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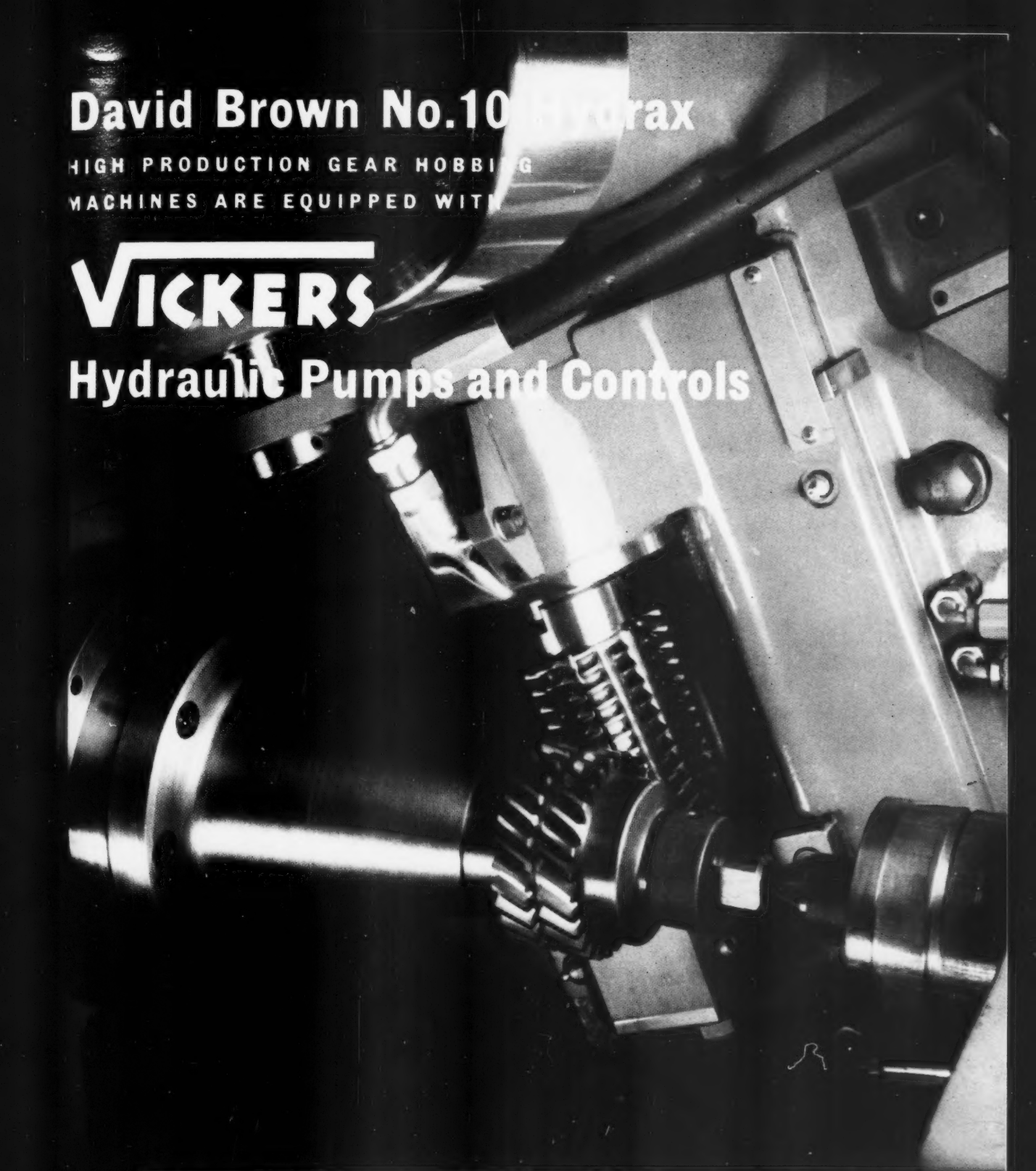

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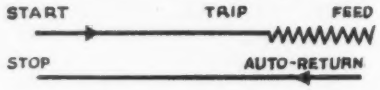

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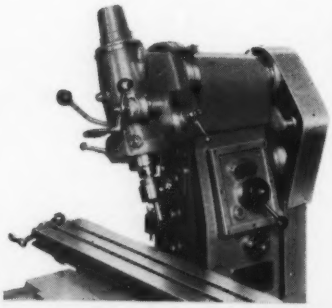

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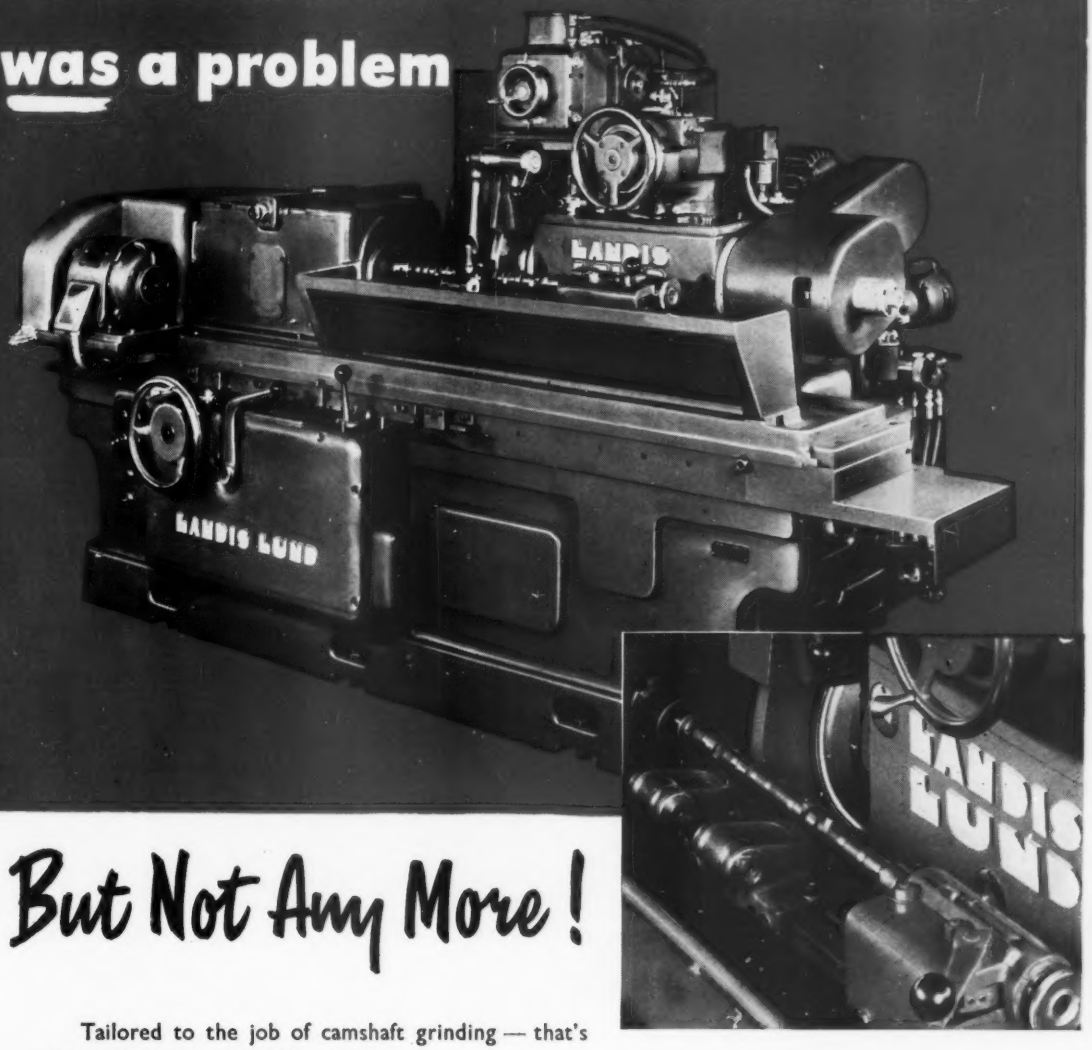

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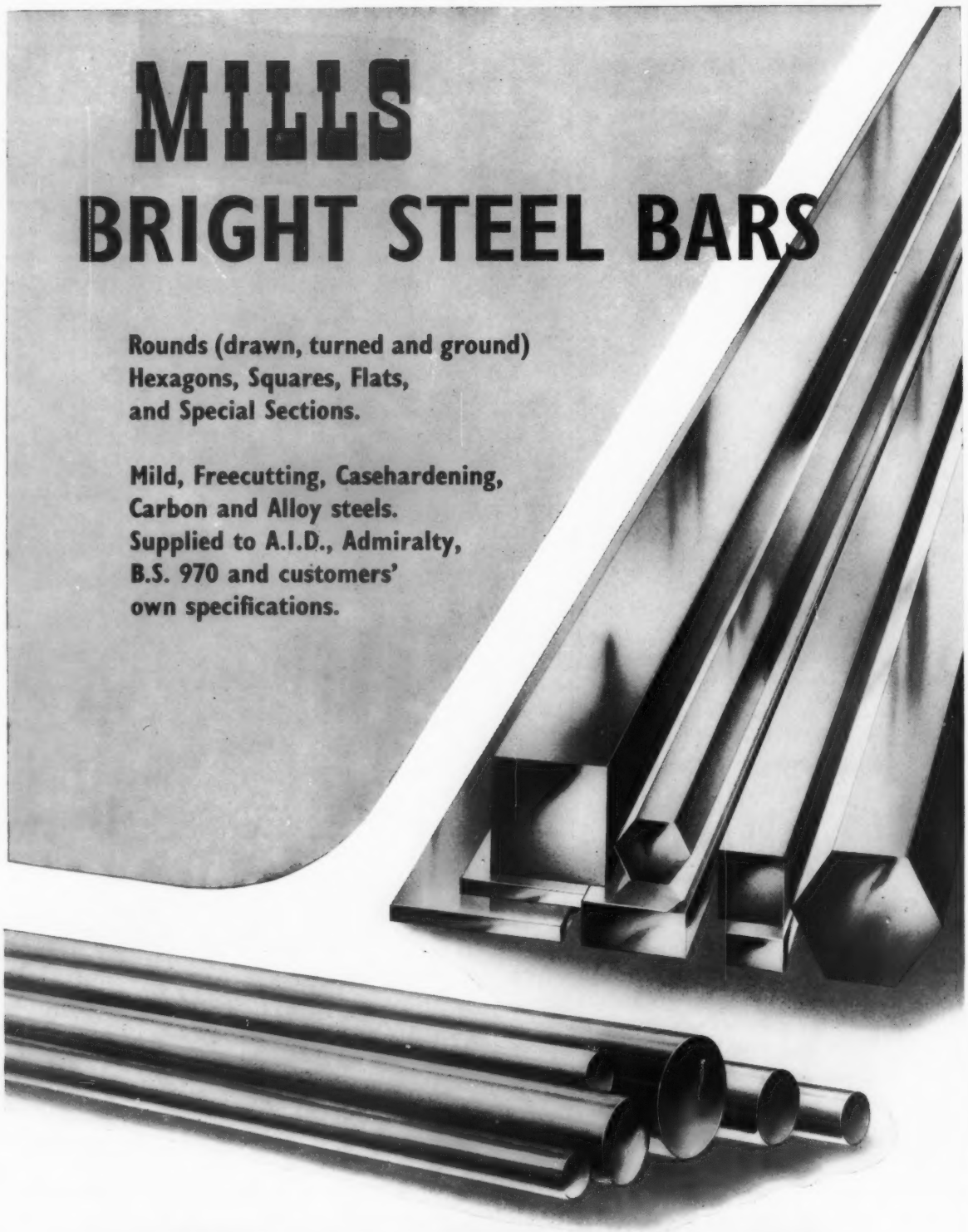

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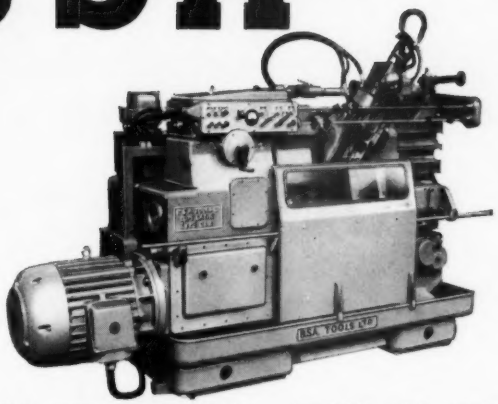

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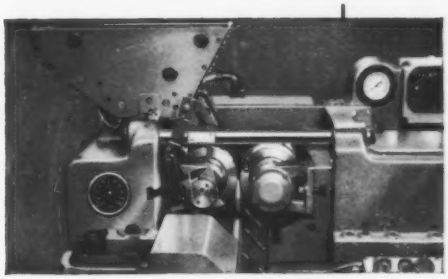

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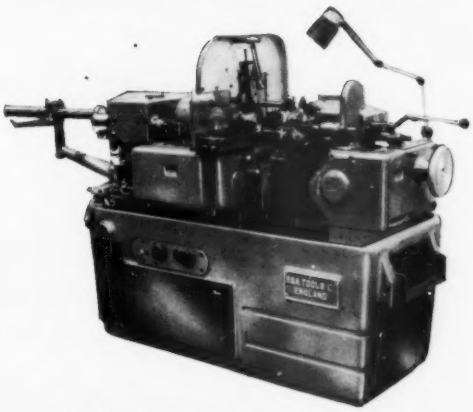
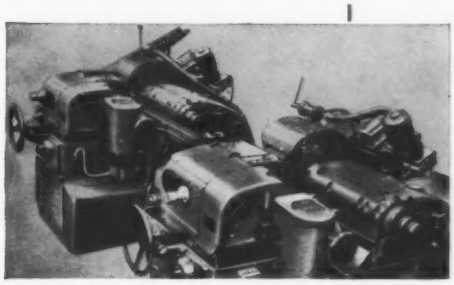
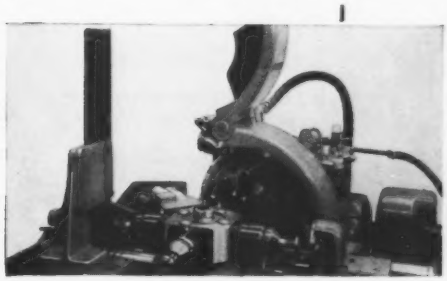


B.S.A. single-spindle automatic screw machines are made in several types including ½", ¾", 1", 1¼", 1⅝" and 2" diameter capacity. Turrets have six stations, but eight station turrets can be fitted to the larger machines. All sizes are arranged for double indexing of turret. A wide range of attachments includes screw-slotting, nut tapping, rear end drilling, cross drilling, spindle brakes and devices for automatic loading for second operation work.



Two B.S.A. No. 8 centreless grinding machines linked for transfer of component for two operations. A chute type magazine gravity-loads workpieces to an endless chain conveyor. On completion of grinding on the first machine the components are passed by intermediate conveyor to the workplate between the wheels of the second machine for another grinding operation.



Cup type components delivered from a magazine are received by revolving collets on the turret faces and presented to the chuck for machining from the cross slides on this **B.S.A. 5M fully automatic chucking machine.** Turret index brings a finished component to the station where it is stripped from the collet pneumatically while the succeeding component is being machined. Cycle times : 9 to 15 seconds (depending on the size of the component for which the set-up is adjustable).

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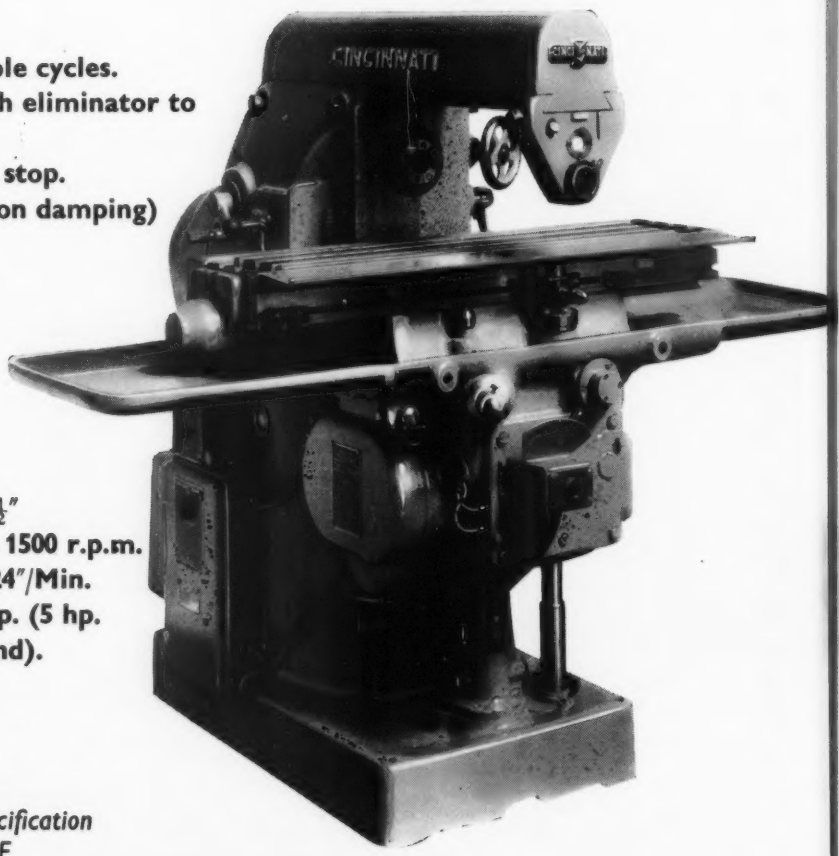

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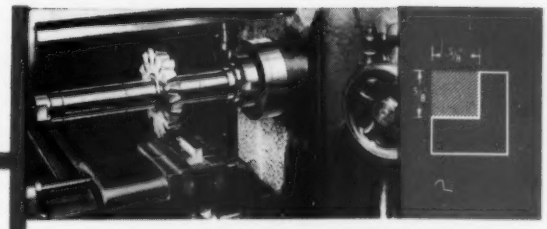
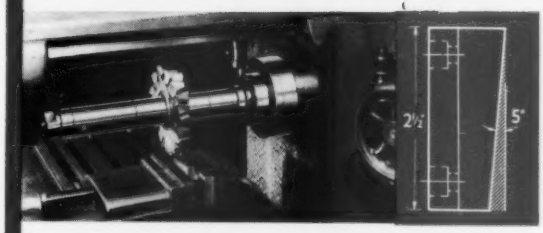


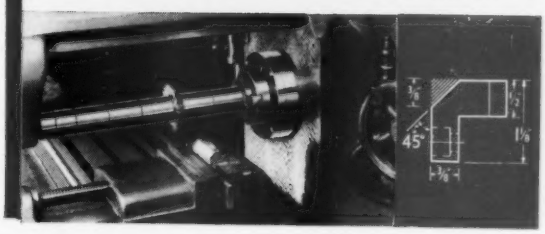
Operation 1

Mill step.
Set-up ... 16 mins.
Milling
(24 pieces) 39 mins.
Total 55 mins.



Operation 2

Mill 5° angle.
Set-up ... 4 mins.
Milling
(24 pieces) 39 mins.
Total 43 mins.



Operation 3

Mill chamfer.
Set-up ... 9 mins.
Milling
(24 pieces) 27 mins.
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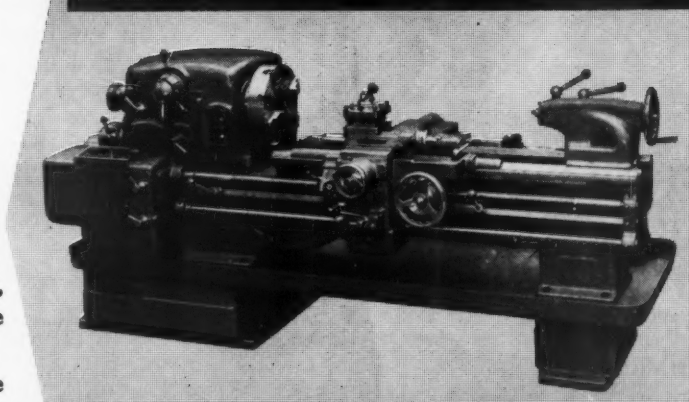

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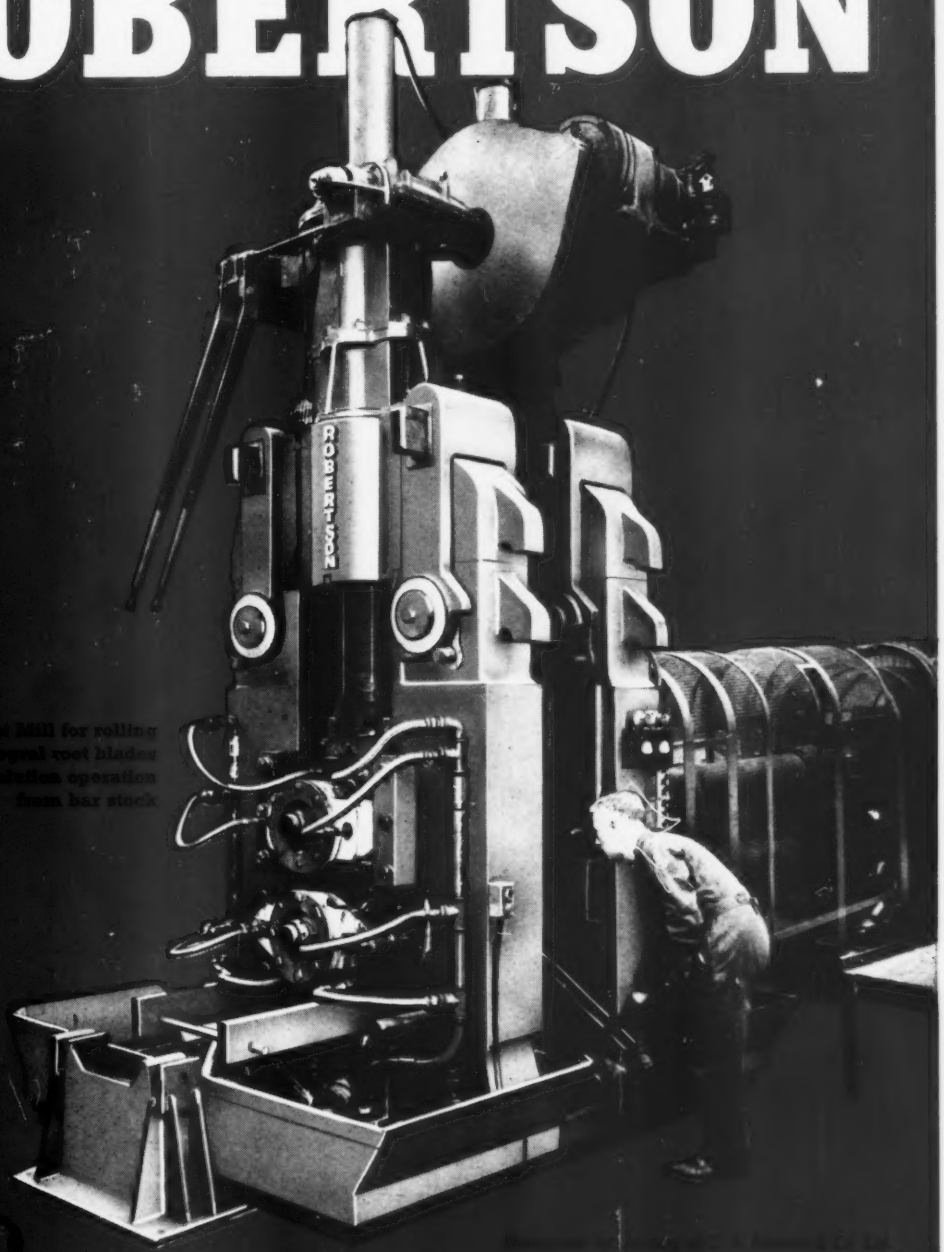

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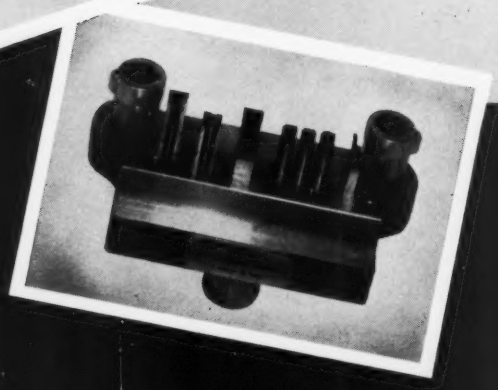

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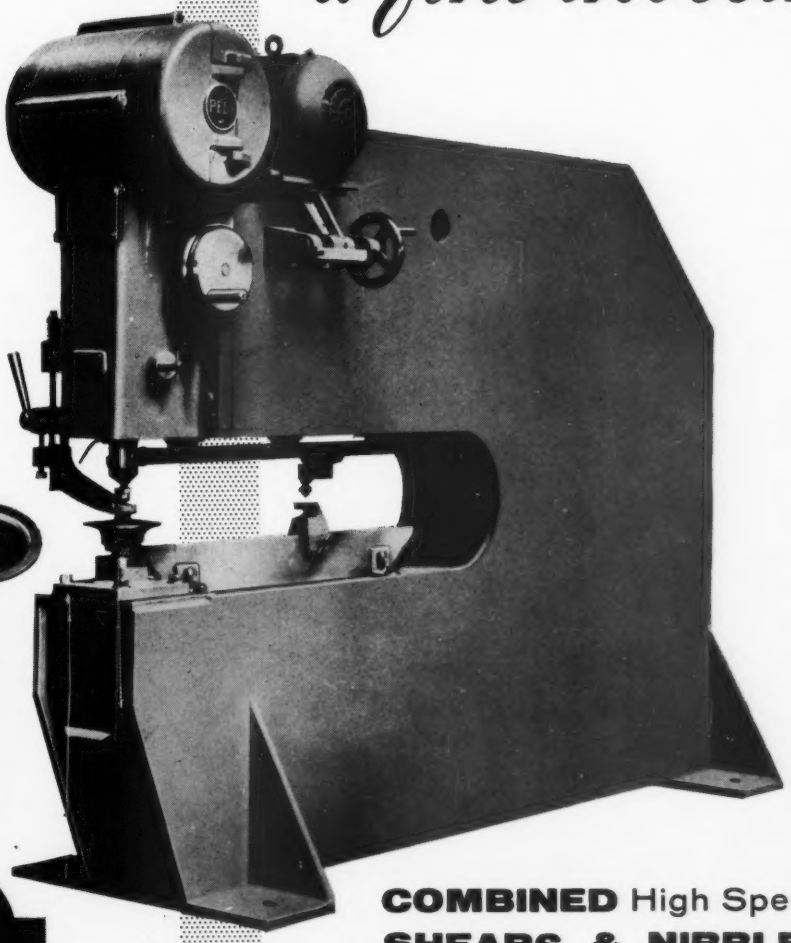

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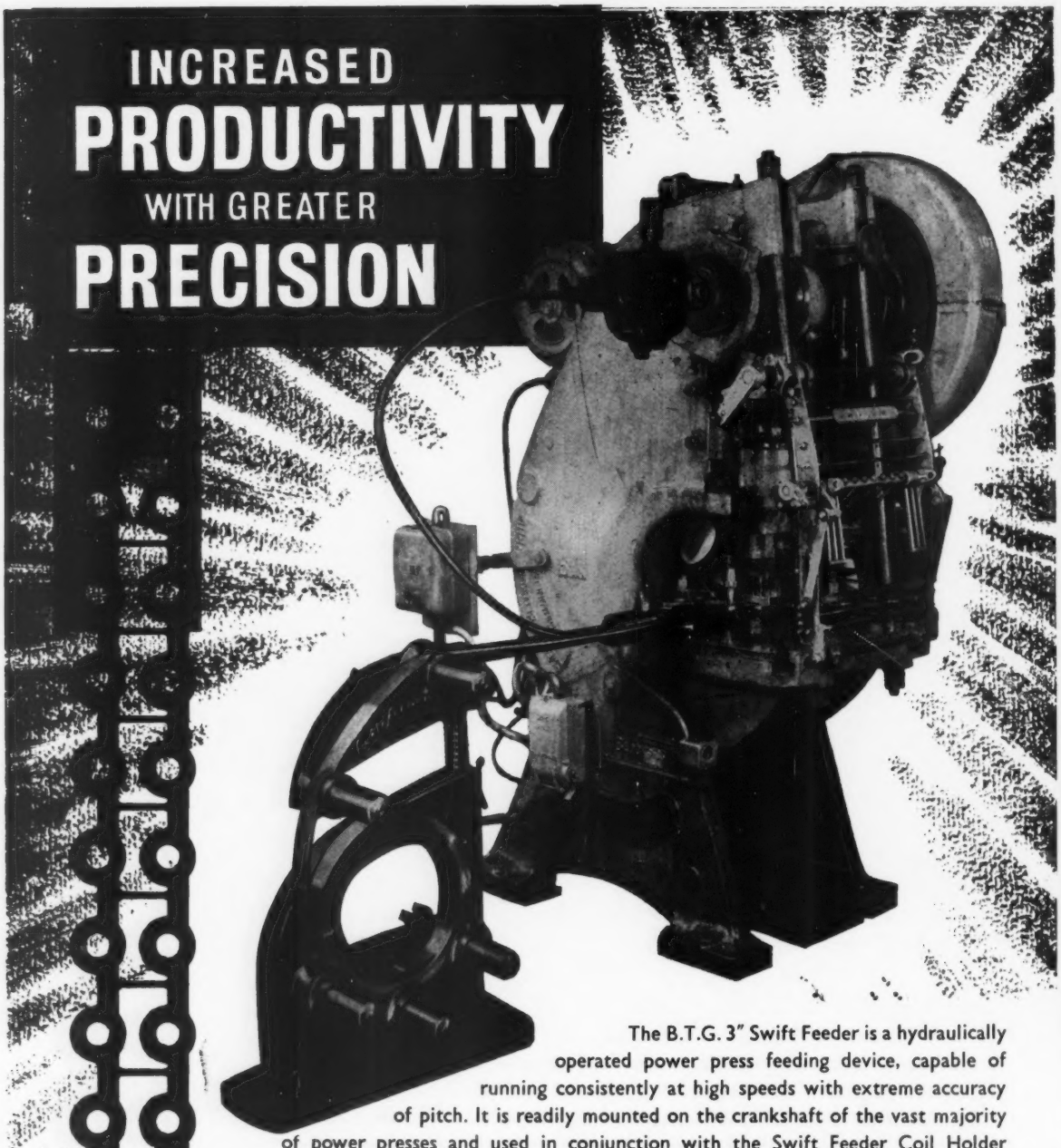

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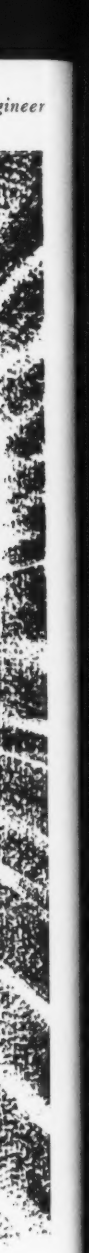

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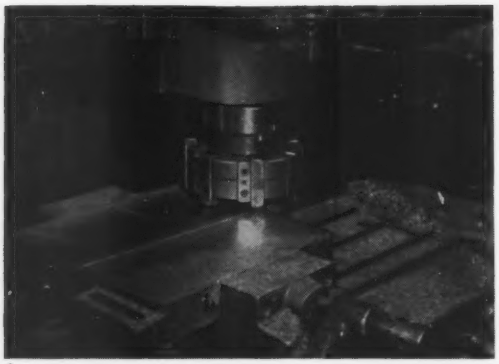

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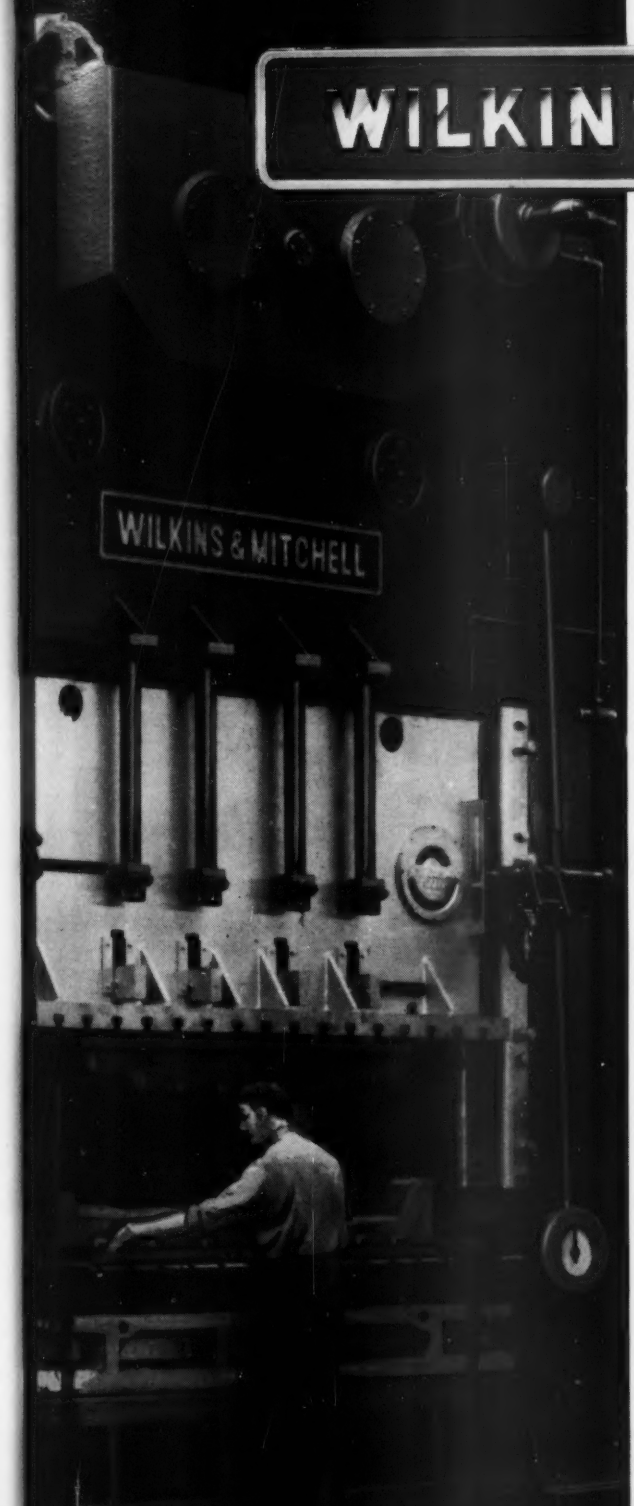

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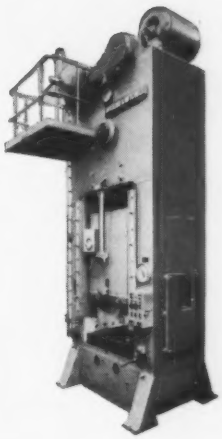

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- HIGH TORQUE CLUTCH
- BUILT-IN DRIVE FOR AUTOMATION FUNCTIONS
- HEAVY DUTY DEEP GUIDED CUSHIONS
- FULL ECCENTRIC DRIVE
- DEEP BEAM ALL-STEEL SLIDE
- ALL STEEL, HEAVY SECTION FABRICATED CONSTRUCTION
- FULL-FLOW CIRCULATING LUBRICATION

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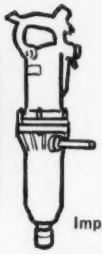
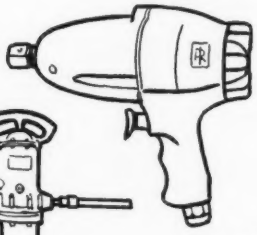
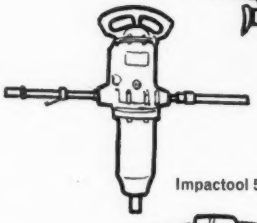
London Office: 70 Park Lane, W.1

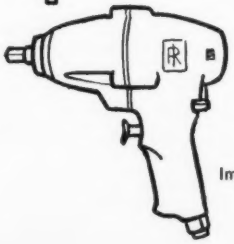
Ingersoll-Rand
COMPANY LIMITED


Impactool 534

Impactool 518


Impactool 5100


Impactool 577


Impactool 5040

The IR range of Impactools has a tremendously wide application. It includes torque control models for work where precision is necessary and runs from ⅜" up to 2" bolt capacity. Low maintenance with maximum power, efficiency and manœuvrability. Reversible models are available and easily changed accessories and attachments give versatility for nut-running, drilling, reaming, tapping, screw driving and all jobs requiring rotary motion

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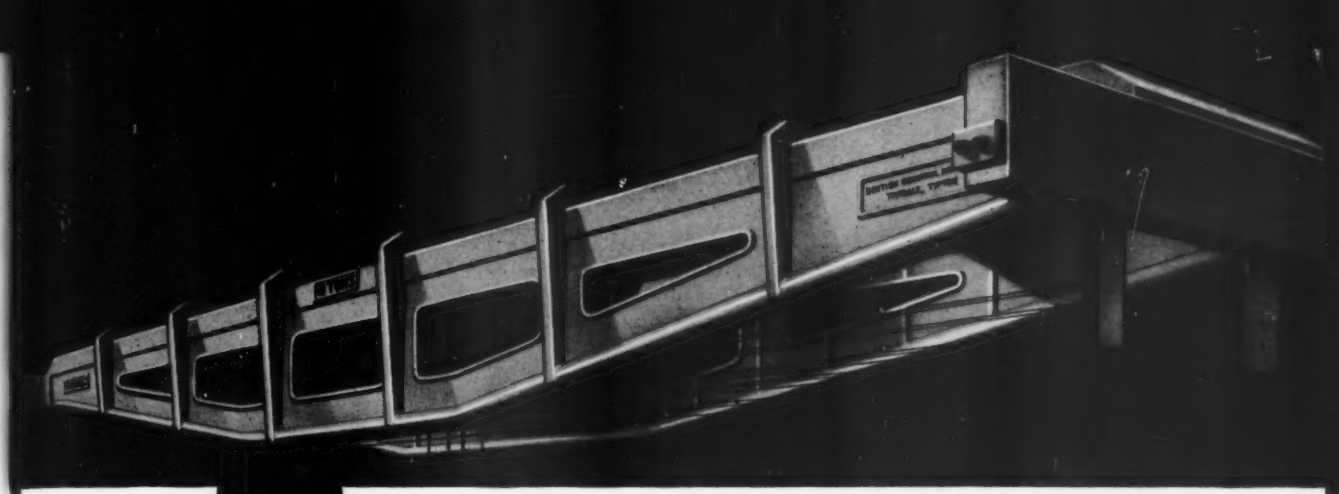
hand held **POWER**

LGB11



Manufactured under licence from Ferrand & Frantz Ing. Villeurbanne. British Patent No. 705, 148.

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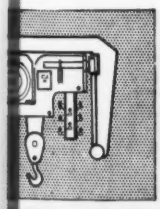
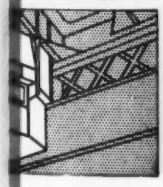
TO SAVE SPACE AND GIVE INCREASED HEIGHT OF LIFT

-with reduced building costs!



The underslung crab unit allows a highest hook position approaching close to the building height.



The driver's cage, glazed or open, is arranged to give maximum possible visibility in all directions.

Reel is the only modern overhead crane specially created to meet modern industrial demands for higher mobility and efficiency. The unique Reel design carries the crane to within inches of the roof, giving maximum height for lifting. Enclosed girder construction combines lightness with great strength, allowing more economical running and maintenance. There are capacities to suit all requirements. Handling of goods is faster, safer and more economical with Reel— Why not contact us now for full information ?

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"RÉEL"

overhead travelling crane

BRITISH INDUSTRIAL

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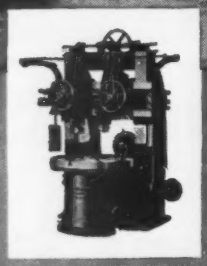

Coventry's Broadgate and a W & B boring mill of the period.

The Changing Years

Over seventy years ago Webster and Bennett began building machine tools and a reputation for quality and value. They have never been surpassed.

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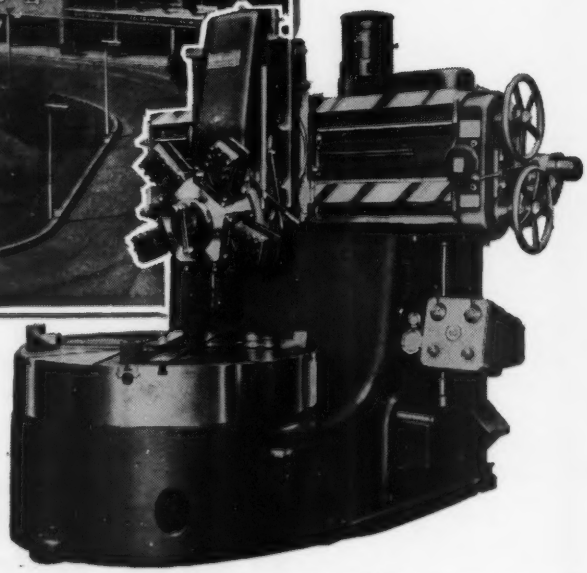
Broadgate today, and the latest W & B design.



Today, **Webster and Bennett boring and turning mills incorporating the most advanced engineering technology continue to enrich their reputation and the future of the people who use them.**

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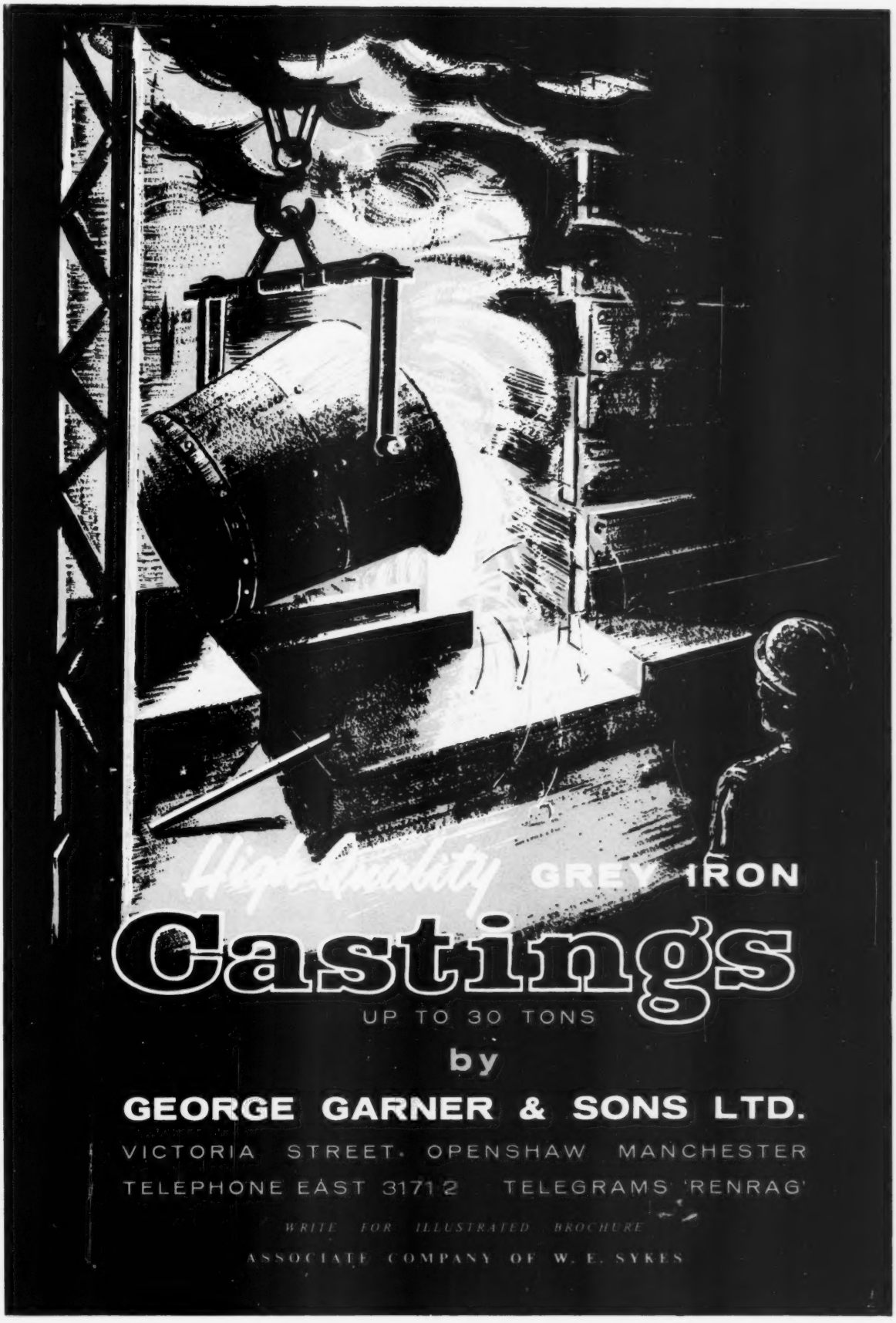
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UP TO 30 TONS
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WRITE FOR ILLUSTRATED BROCHURE
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No need for additional machines and extra floor space

ENM

DIMENSION INDICATORS

* Reduce stoppages for measurement after each cut.
* Increase machine utilisation and output.
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Full technical details on request

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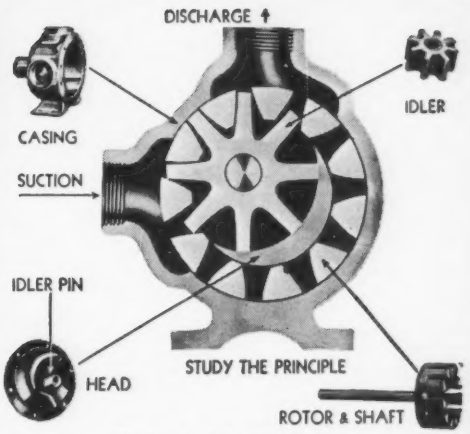
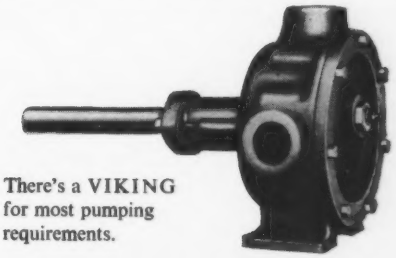
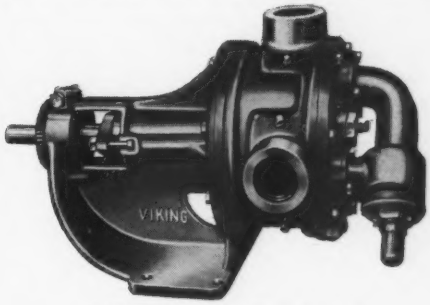
Specialists in the development and manufacture of Pumping, Filtering and Pressure Control Equipment.



The heart of the Viking pump



There's a VIKING for most pumping requirements.



A VIKING Heavy Duty Pump

VIKING PUMPS

range in capacity from 2/3 to 1050 gallons per minute.

More than 750 standard types are available and special models can be supplied to individual requirements.

How to fill vacancies in your D.O. and Stores

With Azoflex papers and a Model 150 automatic Azoflex photoprinting machine, engineering and commercial firms are able to free as many as three out of four operatives and put them on to more productive work. Many of these firms are distributing up to 10,000 copies of assorted parts lists, loose-leaf catalogue pages, memoranda, and other documents up to foolscap size.

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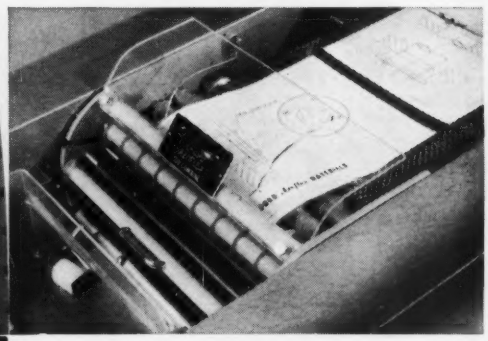

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Many business and industrial concerns find that it pays to hire certain AZOFLEX machines—rather than buy them outright. Enquiries will be treated with the utmost discretion, and will not commit you in any way.

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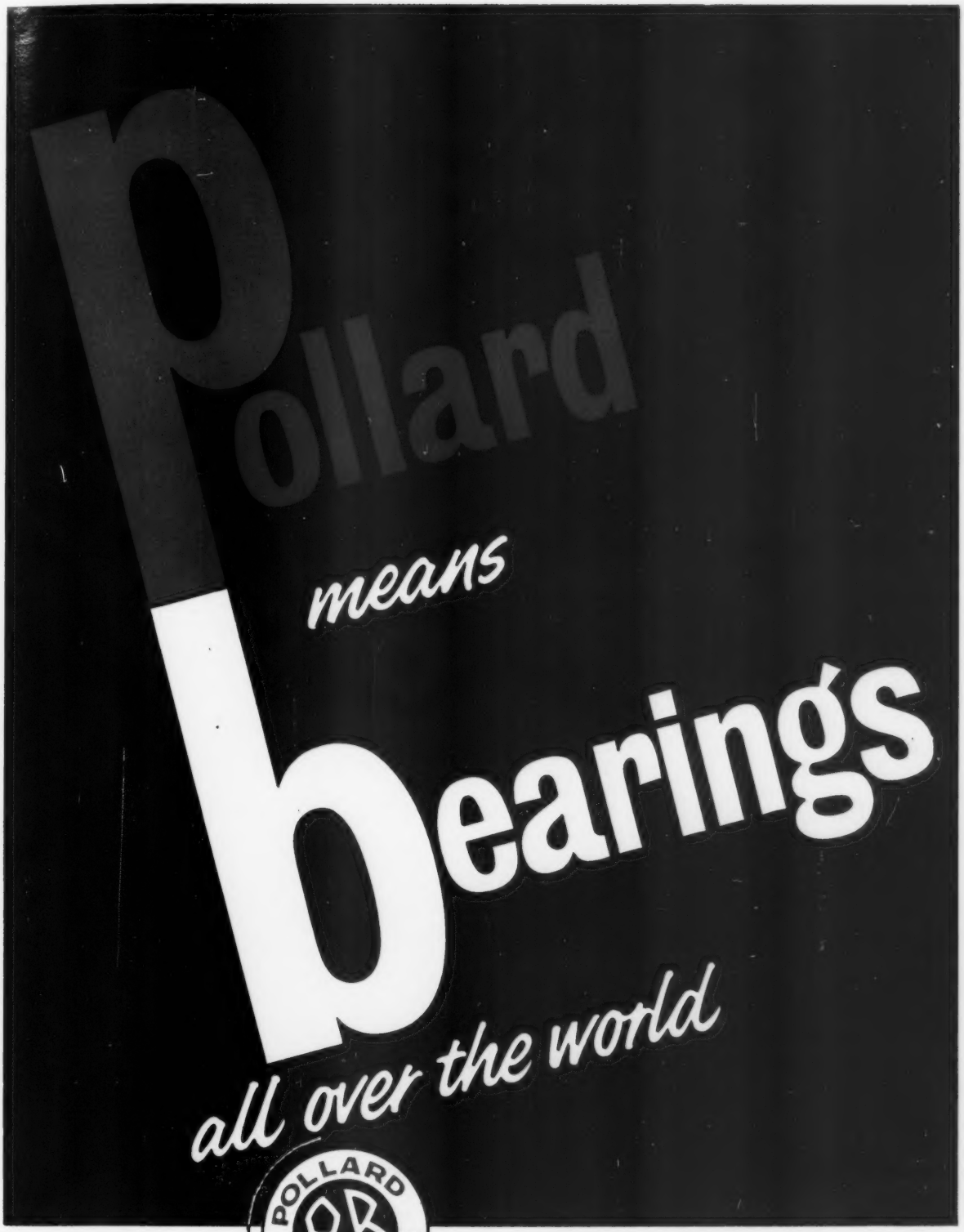

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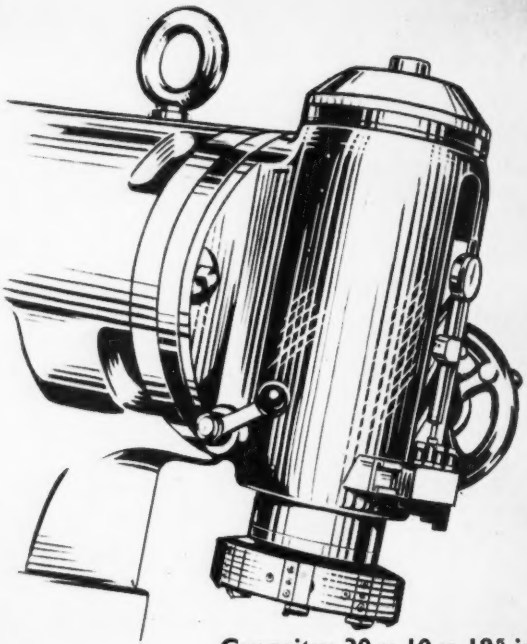

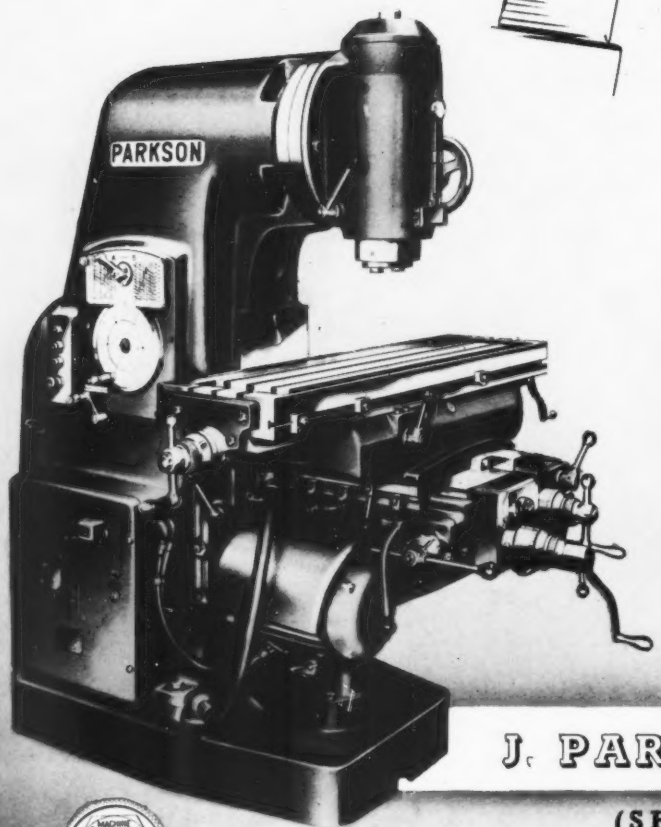

Capacity: 30 x 10 x 18⅝ in.

Power feeds and rapid traverse to all table movements

24 Spindle speeds:
18-1000 r p m
or 24-1330 r p m
or 27-1500 r p m

Spindle Nose: 5⅛ in. dia no. 50 taper hole

Range of
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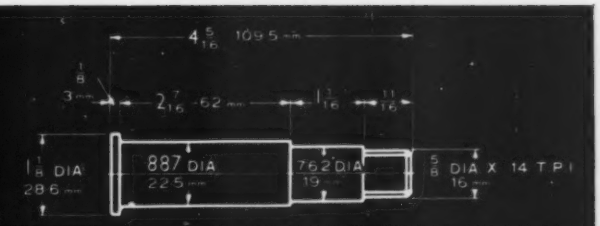

STEEL SPINDLE

1 3/16" dia. Steel Bar E.N.8.
40 ton Tensile Steel
Tungsten Carbide Cutting Tools.

2DS CAPSTAN LATHE

Code Word : **Twods**

Fitted with 1¼" Air Bar Chuck and Air Bar Feed.

Floor to Floor Time :
1 min. 45 secs.

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Max. Cutting Speed		Feed	
	Hex. Turret	Cross-slide		Feet per min.	Metres per min.	Cuts per inch	m/m. per rev.
1. Feed bar to stop & close chuck	1	—	—	—	—	—	—
2. Centre drill	1	—	1110	—	—	Hand	Hand
3. Start turn	2	—	1110	343	104	Hand	Hand
4 Tangential roller turn ·887" dia.	3	—	1110	343	104	130	·195
5. Multiple roller turn 1⅛", ·762" & ·579" dias.	4	—	1110	343	104	130	·195
6. Thread roll ⅝"×14 t.p.i.	5	—	1110	181	55	—	—
7. Roller end and chamfer	6	—	1110	181	55	Hand	Hand
8. Tangential part off	—	Rear	1110	327	100	Hand	Hand

'PRELECTOR' Combination Turret Lathes with Preselective speed-changing.

TURRET LATHES with capacities up to 35 in. swing over bed

1¼ in. to 2½ in. 'D-S' DOUBLE-SLIDE Capstan Lathes for heavier accurate work.

Stock Tools, Toolholders, Chucks and Accessories for Capstan and Turret Lathes.

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BRITISH MACHINE TOOL MAKERS ASSOC. ABMTM LTD

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COMPENSATION FOR WHEEL TRUING

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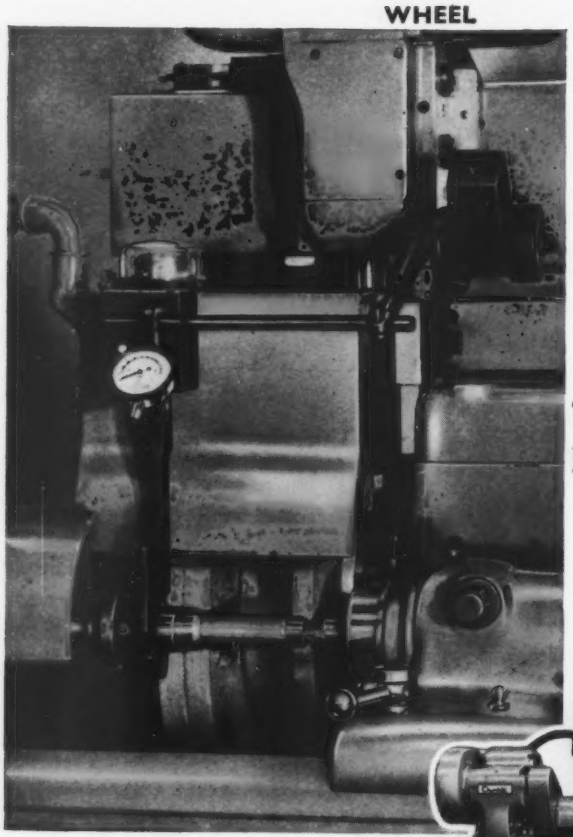

on

Model 'BW' Plain Grinding Machine

THE CHURCHILL MACHINE TOOL Co Ltd
Broadheath, nr. Manchester.
Altrincham 3262

Export Sales Organisation
ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD
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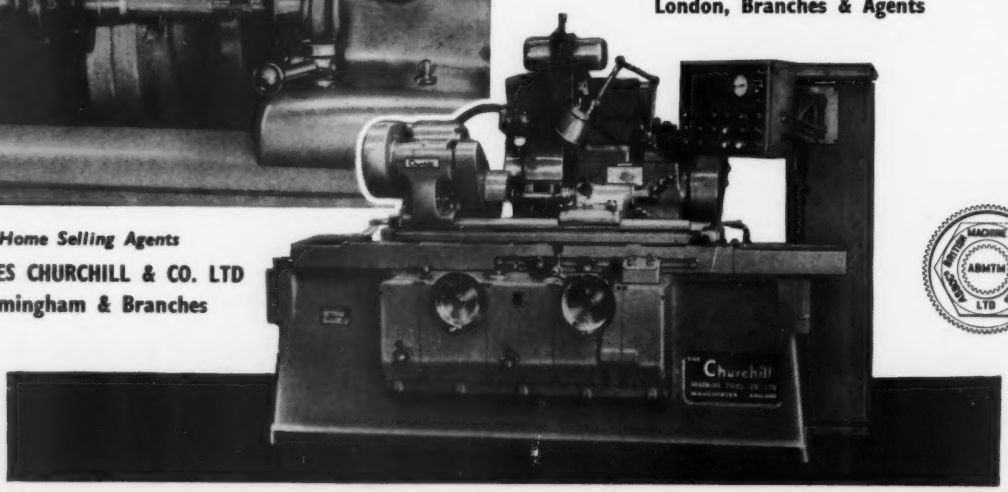

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BY HAND
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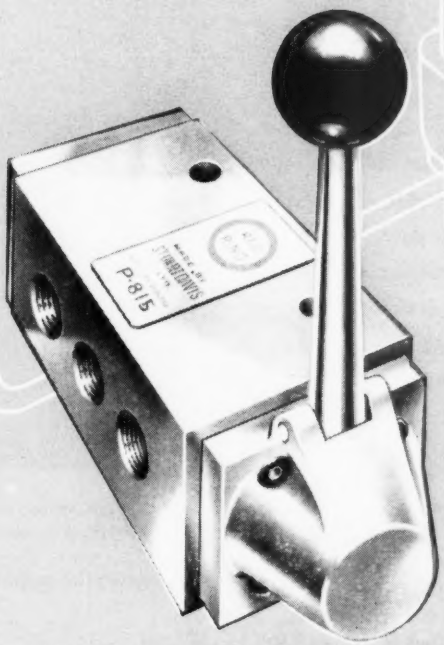

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One of the most popular range of valves is this P.800 series available as lever, foot, toe, air pressure or solenoid operated. The basic valve is engineered to give the maximum number of trouble free operations, unaffected by dirt because it is self cleaning, full air flow through valve giving faster response to cylinders, and easy fixing to any machine, make this range the most versatile available. ¼" and ⅜" BSP sizes.

Manufactured by the Makers of Fine Machine Tools

Stuart DAVIS LTD

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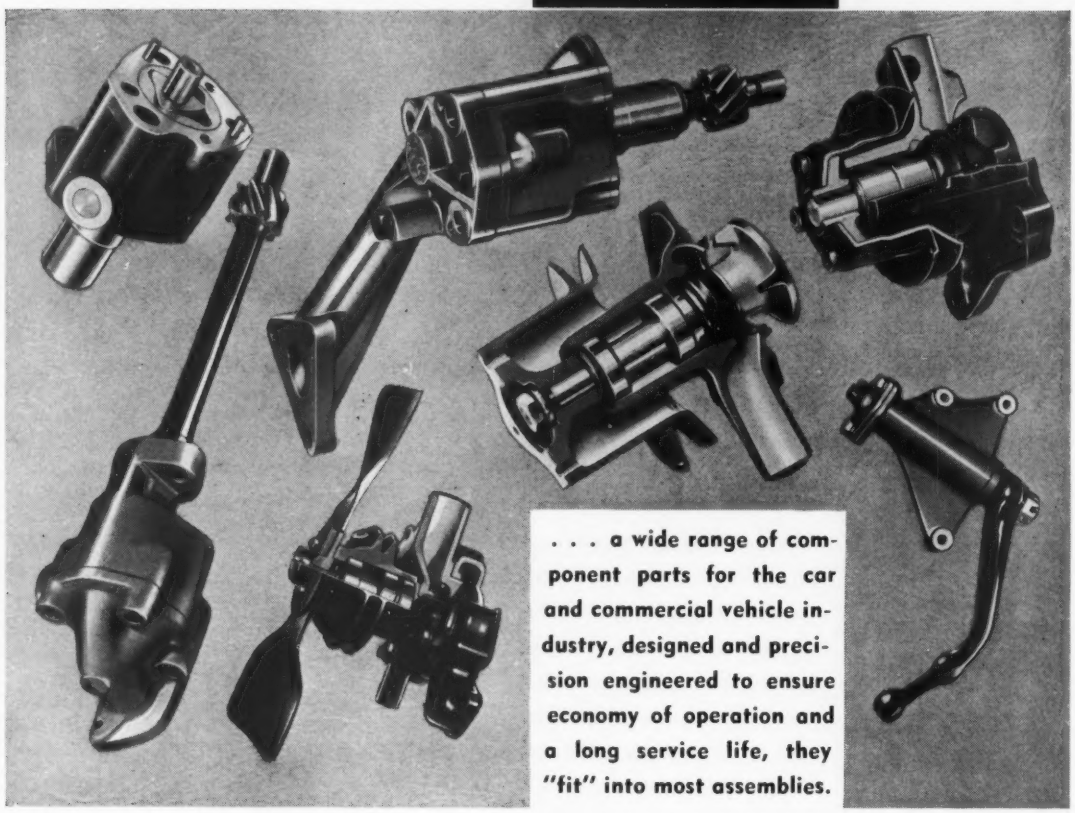
P.E.

CONCENTRIC COMPONENTS



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Concentric, specialists in the design and manufacture of Oil and Water Pumps have achieved a new high standard of performance and production in this field.

Oil Pumps, Water Pumps, Steering Idlers, Clutch Plates, Gear Change Mechanisms, Bearing Boxes, Brake Drums, Brake Discs, Push Rods, Ball Pins, Shackle Plates, Axle and Hub Assemblies, Thrust Plates and Assemblies, Machined Components of all kinds.

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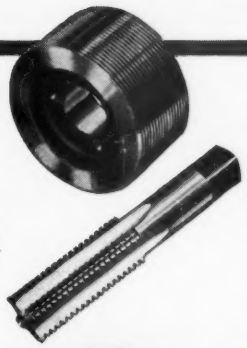
COVENTRY GAUGE & TOOL COMPANY LTD
QUALITY

Thread Grinding Machines

save money on parts like these

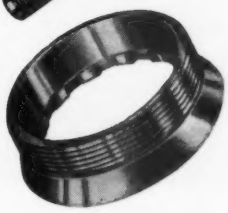


Screw Plug Gauge
2¾" dia. x 11 T.P.I. x 2¼"
Whitworth Form

High Speed Steel Tap
1" x 8 T.P.I. x 2½"
Whitworth Tap
Limits BS949
Grinding Time 80 secs.

Thread Crushing Roller
3" dia. x 8 T.P.I. x 1⅛"
American Form

Micrometer Screw
10mm.x0.5mm.x40mm.
long, S.I. Form
Grinding Time 6 mins.



Internal Combustion
Engine Valve Seat
1¾" dia. x 20 T.P.I. x ⅝"
Whitworth Form
Grinding Time 50 secs.

The various 'MATRIX' Models represent the world's widest range of Thread Grinding Machines.
They will accommodate a range of work extending from the finest threads used in precision instrument manufacture up to a maximum capacity of 14" diameter by 72" long.
The machines embody the latest advances in toolroom and production thread grinding technique and are based on many years of research and development.

Steering Worm
26mm. x 6mm. x 66 mm. long
L.H. Worm Form
Grinding Time 3 mins.

Internal Threaded Component
1½" dia. x 16 T.P.I. x ½" Unified Form
Grinding Time 4 mins.

Screw Plug Gauge
1½" dia. x 4 T.P.I. x 2" Acme.

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MACHINE TOOL CO. LTD.

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Matrix 7

Remove steel fastest . . .

by using Firth Brown high speed steels

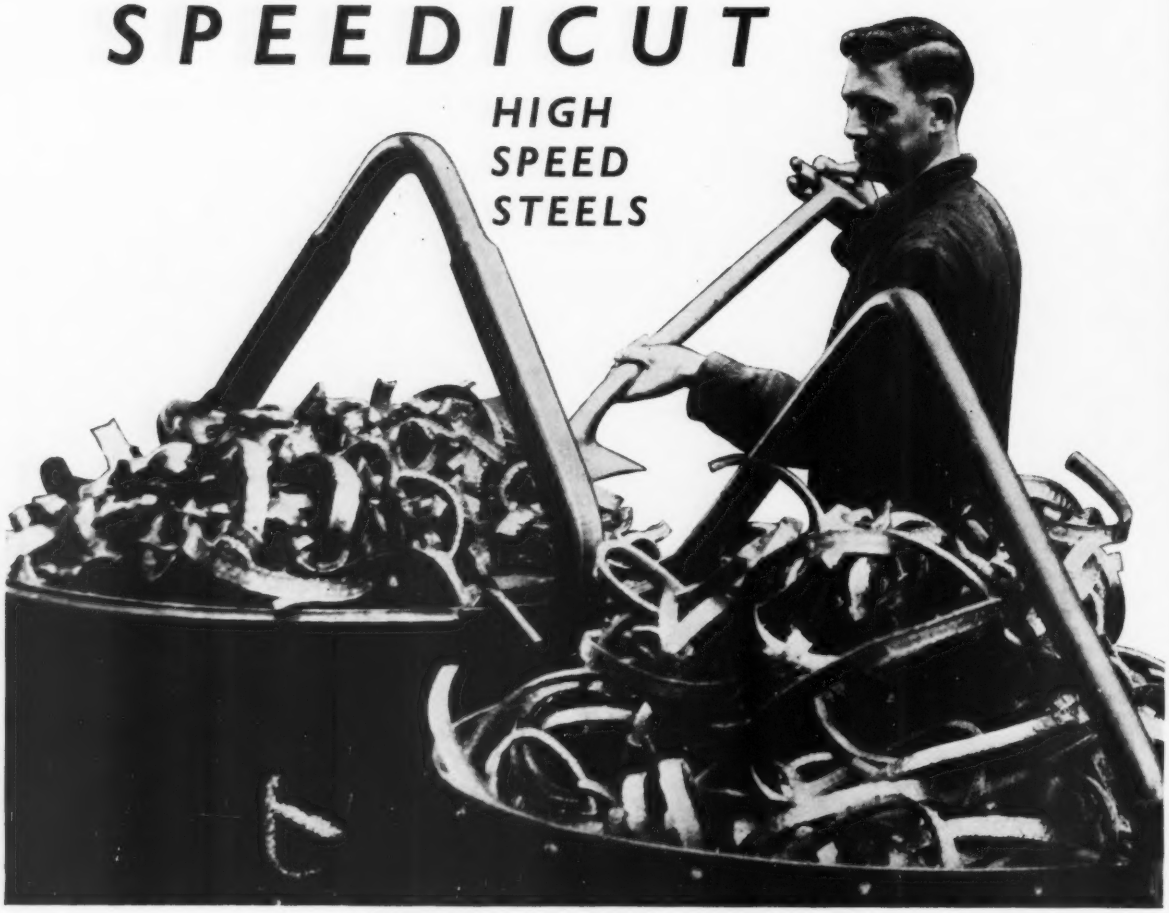
To achieve high production rates in cutting both soft and hard materials in the modern machine shop, efficient high speed steel tools are essential.

The Firth Brown range of highly alloyed tool steels develops an outstanding combination of the principal characteristics required in cutting tools—hot hardness, wear resistance and toughness—which enables them to retain their cutting ability at speeds, feeds and depths of cut.

Send for section 7 of our "Steels" Brochure for fuller details.

SPEEDICUT

HIGH SPEED STEELS



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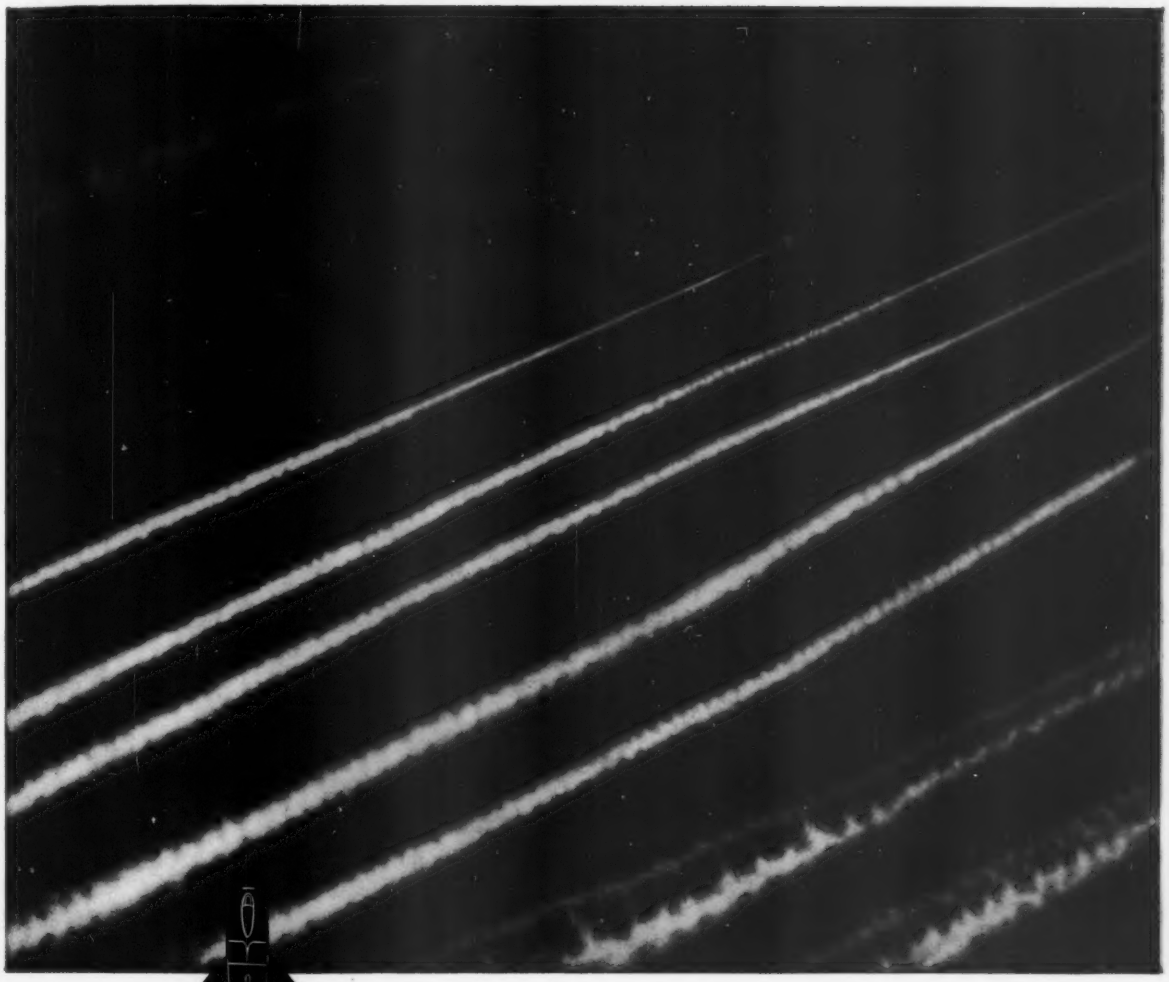
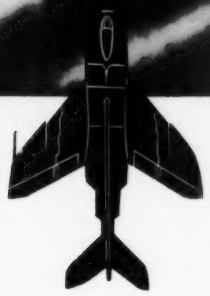
ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS. FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND





Aviation

There are few industries which, for speed of evolution and progress, can be compared with the aircraft industry. The key to this rapid growth has been research, and it is in this field that 'VSG' variable delivery hydraulic pumps and transmission gears have played an important part not only in this country but overseas.

Test rigs of various kinds both for airframe and jet engine development have incorporated 'VSG' equipment as being most suitable for giving that precise control necessary to simulate the required conditions.

This is just another of the highly varied applications of 'VSG' which has now been serving modern industry for over fifty years.

'VSG'

Regd Trade Mark

SERVING MODERN INDUSTRY

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World-beating value

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MODEL

2 AGU

UNIVERSAL MILLING MACHINE

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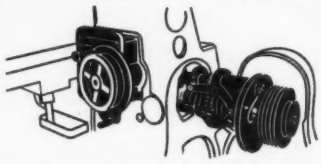

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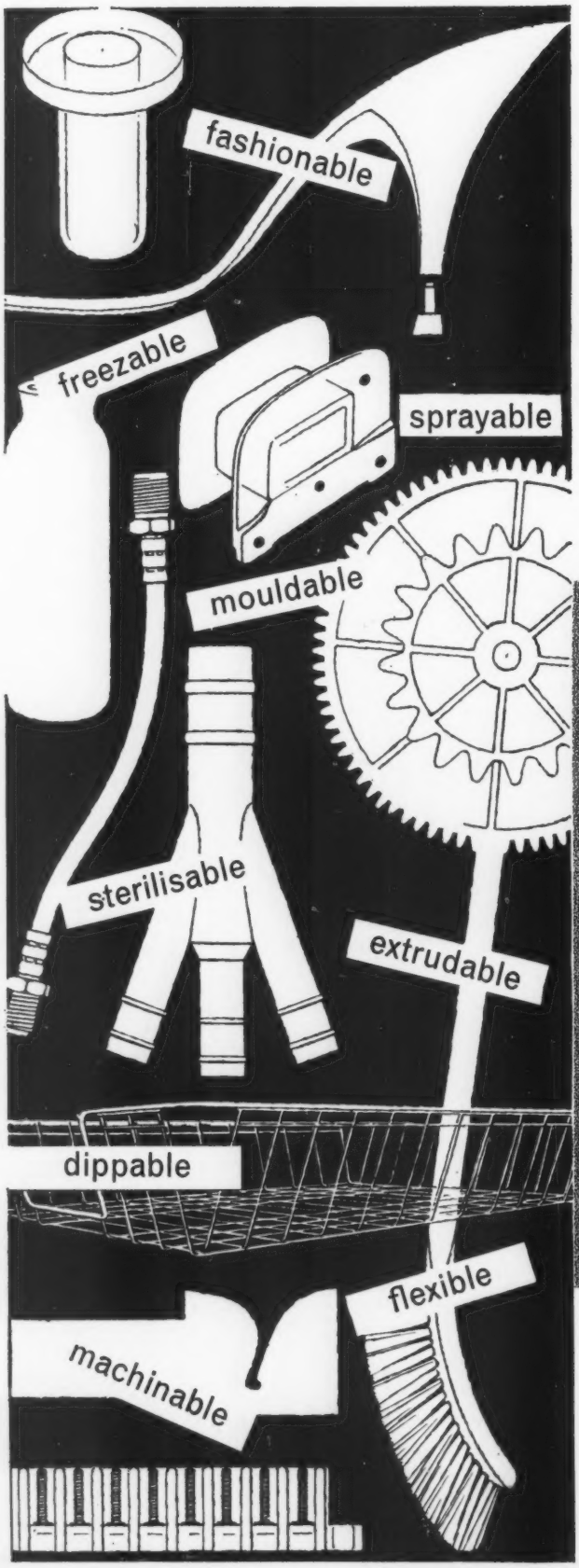

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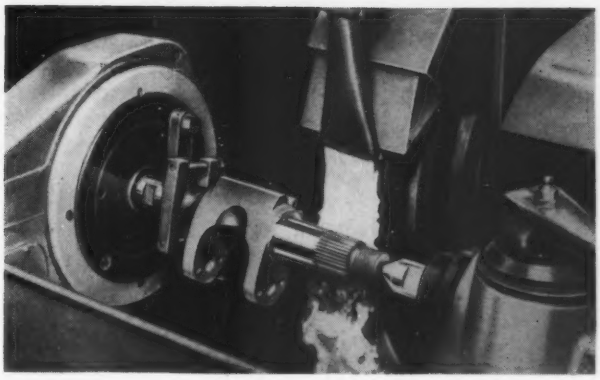

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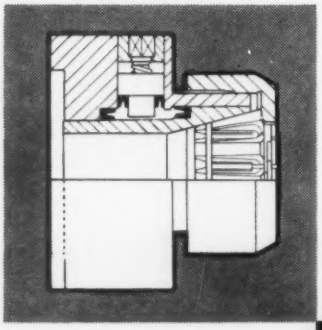

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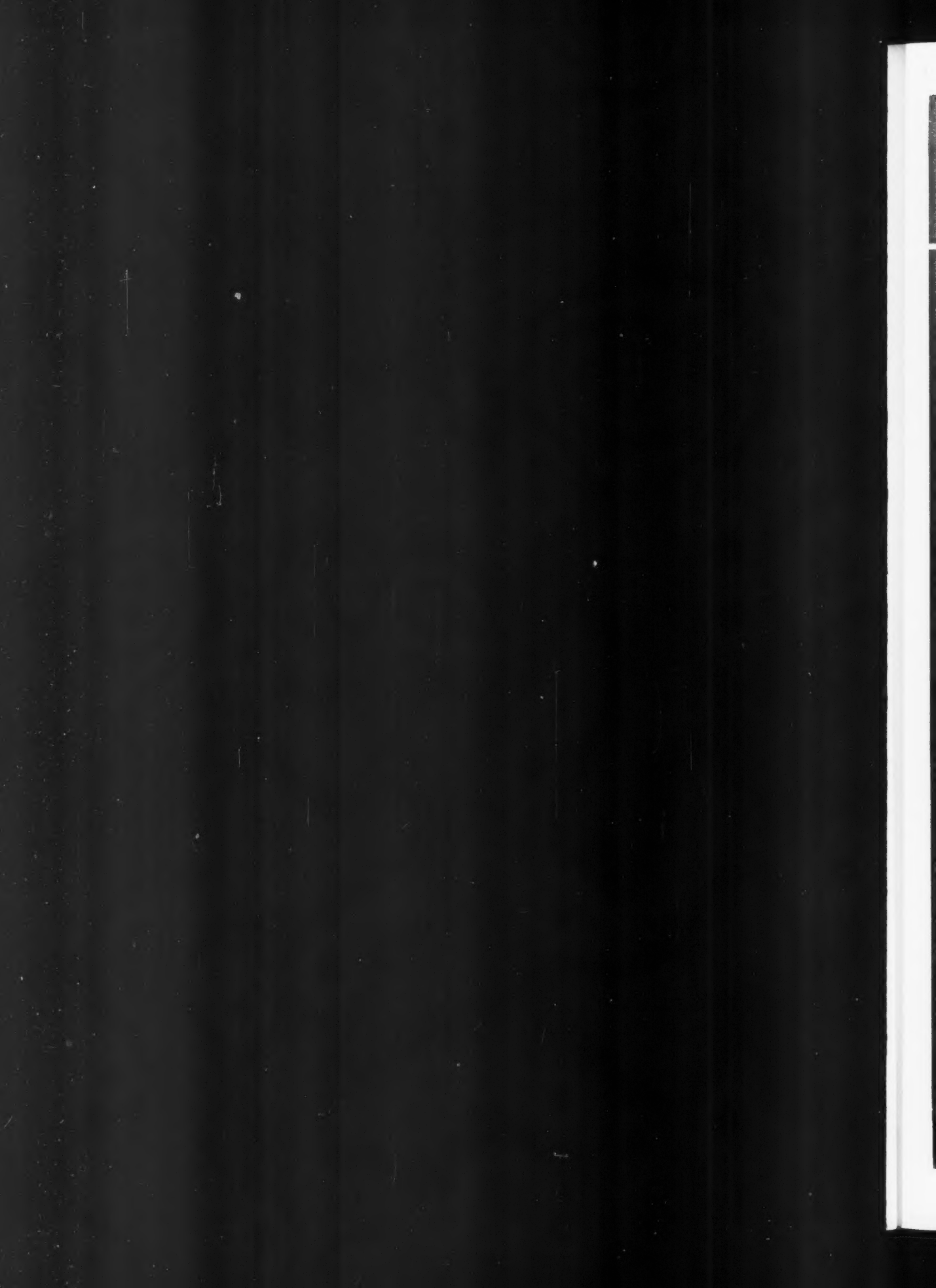

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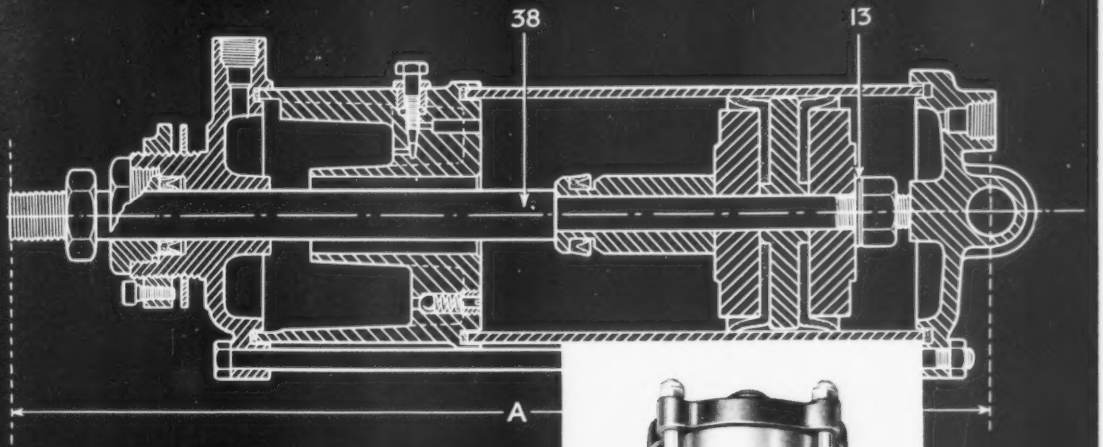

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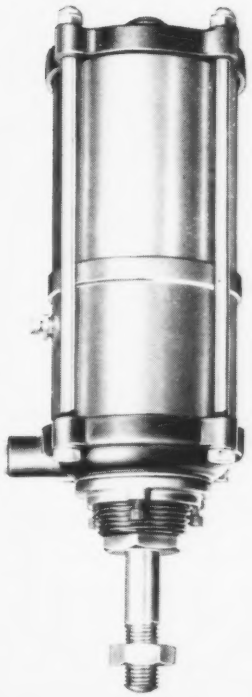

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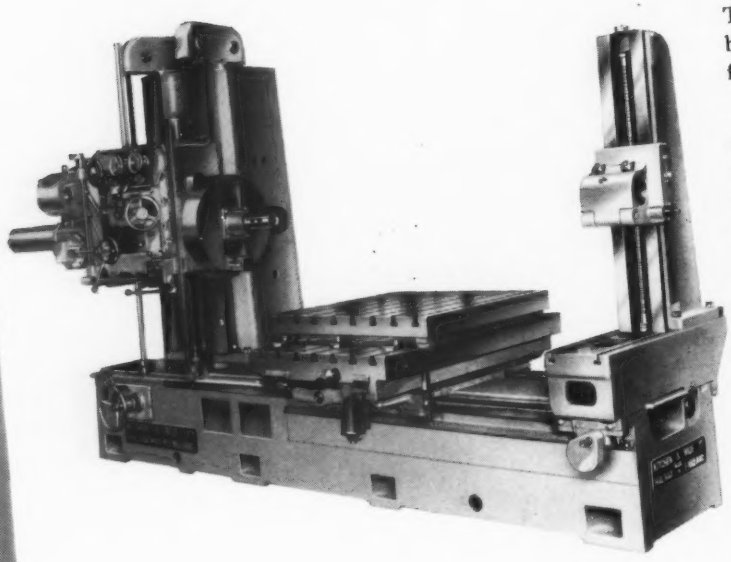

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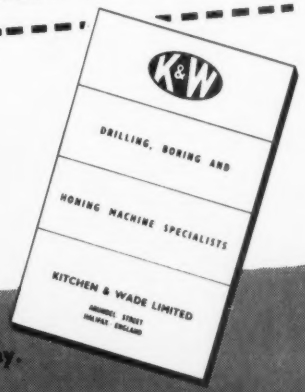

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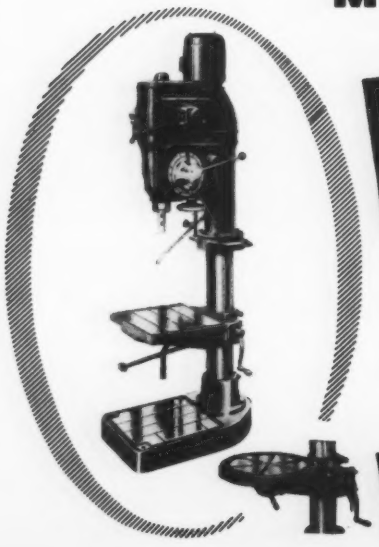

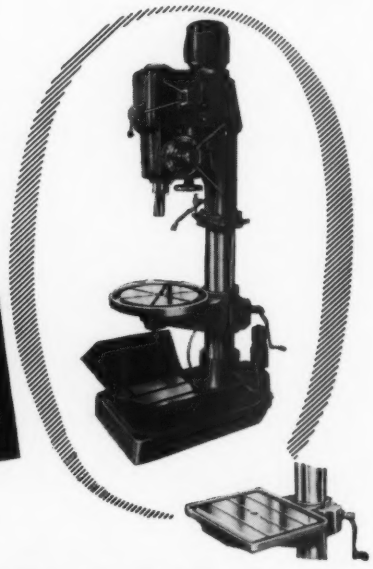

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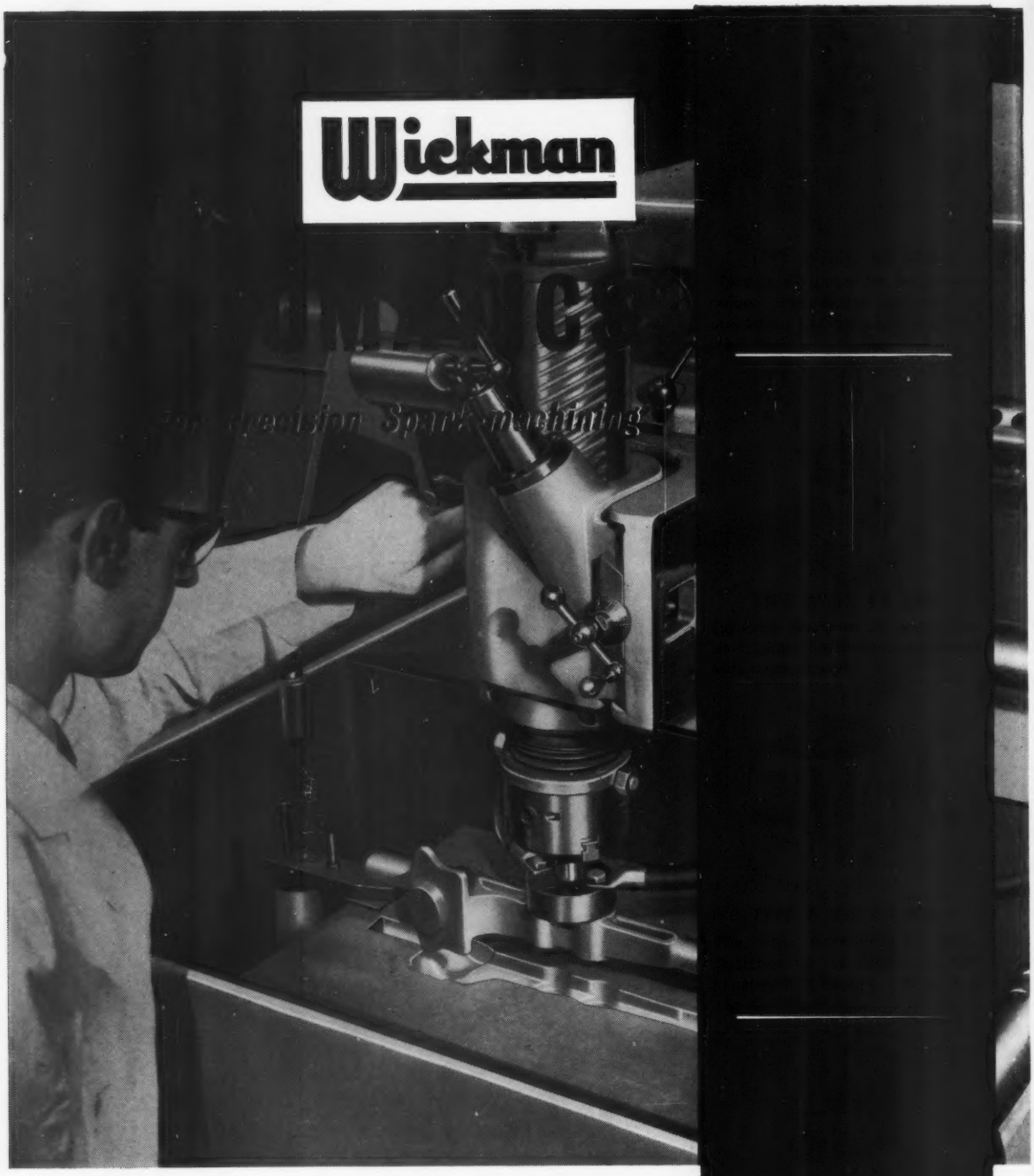

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The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 40 No. 1 JANUARY, 1961

THE DOCTOR IN INDUSTRY

FACTORY MEDICAL SERVICES

by RONALD E. LANE, C.B.E., M.D. (Lond.), M.Sc. (Manchester), F.R.C.P., F.R.S.H. (Hon.), D.I.H. (Hon.)

Professor Lane has occupied the Nuffield Chair of Occupational Health in The University of Manchester since 1945, and for many years prior to this appointment was concerned with the study of health in industry. He is also Honorary Physician to Manchester Royal Infirmary, where he has beds and an outpatient clinic for industrial cases.

He is Consultant to the Chloride Electrical Storage group of companies, to the Central Electricity Council and to the Central Electricity Generating Board. He serves on various Government Committees and is Chairman of the Occupational Health Committee of the Medical Research Council.

This Paper was presented to The Institution of Production Engineers as The 1960 Sir Alfred Herbert Paper, on 10th November.

INDUSTRIAL medicine is concerned with the care of man in the environment of his work. It is concerned with the accident to the apprentice and with the production manager's nervous breakdown, with the effects of a new chemical and the design of the typist's chair. In industrial medicine we see the same two broad divisions that are recognised in medicine as a whole —treatment and prevention. In an outbreak of dermatitis, for instance, the doctor has two distinct functions: the first is to treat the patients and promote the healing of their skin—this is the traditional medical role. The second is to contribute his knowledge for devising measures to prevent a recurrence of the incident.

This preventive side of his work is particularly important in industry and today it is becoming increasingly complicated. It may need the collaboration of other experts—the health engineer, the chemist, the physicist and the psychologist. It is true that the doctor in industry can make some of his most important contributions through teams composed of various of these specialists. It must not be overlooked, however, that the treatment side in industry is considerable and is larger than is sometimes realised. For the doctor in industry not only has the clinical care of special groups of workers, but also has an important part to play in the final stage of the treatment of many of those who have had a serious illness. It is axiomatic that treatment is not complete until the patient is back at work and earning a wage. Sometimes

this final objective is particularly difficult to achieve without the contributions of the industrial medical officer. Here he is collaborating closely with the various branches of the National Health Service on the one hand and the various ranks of management on the other.

The doctor in industry has a difficult role and his success will depend both on a sound basic training in industrial medicine and on his capacity to influence and work with a wide variety of people. Success will depend on his complete integrity and a due humility. He can best serve industry and those who work in it if it is clear to all that he takes no sides in the employer/employee relationship and if he approaches his task with a minimum of emotion and a maximum of factual data. It cannot be over-stressed, however, that the ultimate success of a health policy in any industrial undertaking rests with the attitude of management and the co-operation of the workmen. For this reason I—as one deeply interested in industrial health—am grateful for the present opportunity to discuss this branch of medicine.

the history of industrial medicine

The process of industrialisation in the United Kingdom brought many medical problems, both social and industrial, and from the beginning there have always been those who have led the way to improvement by voluntary effort. For instance, we are apt to regard the employment of children in our early factories as inhuman. Doubtless at times it was, but I was interested a few years ago to find when I visited Quarry Bank mill near Manchester that as early as 1789 the employer had arranged for the special medical supervision of these children. The doctor visited the apprentice house weekly and prescribed treatment.

But, of course, voluntary effort is frequently patchy and there have always been those who have not been so concerned over the health of workpeople. Practice has lagged behind knowledge and Parliament has had to take a hand to ensure minimum standards. The manner of early growth of our industrial legislation was discussed by Merewether (1948) in his Bridge Memorial Lecture. He concluded that not only was change slow to come, but Parliament appeared to take great care to do as little as possible. There is no evidence of inspired vision or comprehensive appreciation of a vast and changing problem Instead, throughout the 19th century industrial health legislation was made piecemeal. To begin with attention was directed to the care of apprentices in textile mills, followed by control of hours of work, accidents from factory machinery and the industrial diseases.

In 1844 we find the first requirement to appoint " persons practising surgery or medicine." These Certifying Factory Surgeons had to certify the age of children working in the factories (it was before the compulsory registration of births). This must be regarded as the beginning of the statutory industrial medical service; for the next 60 years it did remarkably little. Not until 1898 was Thomas (later Sir Thomas) Legge appointed to the newly created post of Medical Inspector of Factories. He put industrial medicine on the map and although there have been other distinguished Medical Inspectors of Factories who have contributed much to the industrial health of this country and the world, Legge was the pioneer. It is from this background that we have our present day statutory industrial health services with Medical Inspectors of Factories and part-time Appointed Factory Doctors.

At the same time the more enlightened firms, where the owners and managers took considerable care of the health of their employees, gradually developed their own voluntary industrial medical service. Sometimes the stimulus for this was the presence of an industrial hazard. To take a recent example, during the late 1920's cases of lead poisoning continued to appear in a factory in Manchester manufacturing electric accumulators despite precautions. New statutory regulations had been introduced in 1925 to control conditions in the industry and although these brought a fall in the number of cases of disease in the country as a whole, the incidence of the disease in this particular factory remained constant (this is not difficult to understand for the regulations were based on the best known current practice which was that already in use in the factory in question). In fact, the firm was expanding and the number of cases continued to rise and the Company decided to appoint a doctor to advise it.

Here there was a hazard which presented medical problems. These were investigated, safe limits of atmospheric contamination were established and methods of individual control were worked out. As a result lead poisoning was stopped and in a few years the level of lead absorption was reduced to safe limits. It must be stressed that the safe conditions had to be designed and installed by engineers; it was they who dispensed the prescription written by the doctors.

As well as the statutory and voluntary industrial medical services there have been other influences. It was not until nearly 100 years after Parliament first began to legislate for the care of those employed that it made the provision of compensation of the injured workman compulsory. There can be little doubt that this acted as an inducement to improve working conditions. At the same time some larger firms, to help them deal with the claims made under the Workmen's Compensation Act, employed full-time doctors. Although the National Insurance (Industrial Injuries) Act of 12 years ago brought fundamental and far-reaching changes in these arrangements, the former idea of the " company's compensation doctor " still dies hard with some men and some managements. It must be admitted that this forms another, if less distinguished, progenitor of the modern industrial medical service.

The fact that industry can play a part in the final stages of treatment of disabled people has been recognised by Parliament since 1944. Since then, under the Disabled Persons (Employment) Act employers are under a statutory duty to employ at least 3% of registered disabled people. For this piece of progressive social legislation we are largely indebted to the late Ernest Bevin.

present day services

And so we come to the present day. A sound basis for industrial health has been established by law. The responsibility of the employer for the health of his employees has been firmly established. This responsibility is becoming increasingly onerous since standards are constantly rising and modern industry is imposing new stresses. There are, as we have seen, some employers who have voluntarily set up industrial medical services to meet the new requirements. But the gap which exists between the standards of the enlightened and the minimum required by law is widening. At the present time there is considerable interest in the form any new advances in our industrial health services should take; it seems opportune, therefore, for professional groups to examine the position. If changes are to be made, what forms should they take and how far should they go? These are questions which must be answered clearly if the present opportunities are not to be missed. Before an attempt is made to answer them, the present-day position of medical services will be considered.

Our industrial medical services in this country remain quite distinct from the National Health Service. As a result they are not administratively tidy and the present arrangement doubtless has certain disadvantages. On the other hand, it is essential that an Industrial Medical Service should be closely integrated with industry and there is much to be said in favour of much of our present system.

Since the interest of my audience is likely to be mostly with factories, I intend to confine myself to the factory medical services. It should not be overlooked, however, that there are well-organised services provided outside the factory system. The National Coal Board and The Atomic Energy Authority, for instance, have a highly effiicent medical service, including both environmental and research sections. The same applies to the London Transport Executive and certain other of our transport services. There are, however, large areas of employment where there is no such service or it is of only a rudimentary character. Agriculture, for instance, is one of our largest industries but until recent years little attention has been paid to health problems. Now there are codes of regulations designed to prevent accidents and danger from poisonous substances such as may be used in the control of pests and weeds. Working conditions in offices and shops have often left much to be desired despite the Gowers report. It is to be hoped that the promise of early action in this sphere will not fail.

Turning to our existing factory health services these are of two types—statutory and voluntary.

the statutory services

The statutory services are based on Factories Acts. These require the provision of a good working environment, standards for cleanliness and sanitation are laid down and those for lighting, heating and ventilation are prescribed and minimum arrangements for first aid are required. In addition, special codes of regulations prescribe conditions for the dangerous trades. These statutory requirements apply to all factories and there is no doubt that they are the backbone of the factory health service in this country.

The Minister of Labour is responsible to Parliament for this service, and he is advised by a recently reconstituted Industrial Health Advisory Committee. This Committee carries considerable responsibility for the development of industrial health in this country. Employers and workers are represented on it as well as various specialists in industrial health.

The Factory Department of the Ministry of Labour is responsible for the enforcement of the Acts through the Factory Inspectorate. This consists not only of some 350 general inspectors but also of a number of specialist inspectors, medical, engineering, electrical and chemical.

The Medical Inspectors of Factories work largely on a regional basis. They constitute a distinguished if small group and over the last 60 years these Medical Inspectors have been responsible for not a few of the advances in industrial medicine. Legge's early work on anthrax and lead poisoning; Collier's on the dust diseases and Henry's painstaking investigation of skin cancer are all classical contributions. The number of medical inspectors has recently been increased, but even now they are far too few and are too thinly spread for them to be able to visit the factories in their region at reasonable intervals, and also keep in close touch with their professional colleagues in other branches of medicine.

The main function of the Medical Inspector of Factories is the prevention of industrial disease and the supervision of the Appointed Factory Doctors (A.F.D.). These are the modern counterpart of the Certifying Factory Surgeon first appointed in 1844. They are general practitioners with part-time duties in industry. There are some 1600 of them and they carry out duties under the Factories Acts. In the main their work is to examine children of 15—18 entering factories and to examine those who work in certain dangerous trades.

voluntary services

Let me now turn to the voluntary services which have grown comparatively rapidly over the last 30 years. These aim to provide the employer both with better means for carrying out his statutory duties and with a more effective medical service, going beyond statutory requirements. An example was quoted earlier in regard to lead; similar services have dealt with special hazards in the chemical industry and in industries with dust hazards. Improved medical techniques, e.g. better chest X-ray and new laboratory methods, have contributed to improvement in the standard of service available to the workman and have been pioneered by private industry.

But these voluntary services have not been confined to the " dangerous trades "; many firms with a large number of workers have found it worthwhile to engage doctors and nurses whole or part-time. There is at present no accurate list of such staff, but it is estimated that some 350 whole time and 1,500 part-time doctors and some 3,000 nurses are so engaged. It might be well at this stage to give an idea of the accepted

functions of such a service. These fall into two main groups:—

(*a*) those directed to the individual worker to ensure that he is fit for his job;

(*b*) those directed to the environment to ensure it is fit for the worker.

To fulfil these functions the doctors' duties will include:—

(1) giving general advice to management on all matters affecting the health of those employed;

(2) the medical examination of individual work-people and staff;

(3) the provision of casualty services with the organisation of First Aid services where necessary;

(4) the education of employees collectively and individually on matters of general and personal health.

When the National Health Service was introduced in 1948, these services remained outside it and quite separate from it. In 1949 there was a suggestion that the National Health Service was being jeopardised by a staff shortage caused by the recruitment of doctors and nurses into industry, and the Prime Minister set up a special committee under Judge Dale to investigate the situation. This Committee reported in 1951 and their report may be looked upon as a charter for industrial medicine. The Dale Committee was unanimous in accepting the essential importance of the Industrial Health Services which they said " may now be regarded as a normal function in enlightened management." Since this report in 1951 their advance has not been as rapid as could have been hoped, though they have continued to expand.

research

We are fortunate in Britain in having a very strong Medical Research organisation—The Medical Research Council. Among its many and diverse activities it undertakes research in the field of occupational medicine. The Pneumoconiosis Research Unit, sited in South Wales, has over the last 15 years contributed a great deal to our knowledge of dust disease of all sorts, particularly of the dust disease of coalminers. It must be remembered that industrial medicine is a part of general medicine and this unit, as with many of the other " industrial " units, has, in fact, made important studies in related and general subjects; in this case, chronic bronchitis and the relation occupation may have to this disease.

There are units which deal with climate and working efficiency and with environmental hygiene. An important and active unit based on Birmingham Accident Hospital has made a special study of Industrial Injuries and Burns. Much has been learned both of the way to treat serious casualties and also how best to treat the minor or less severe every-day injury of industry. Here again the fundamental problems of wound healing and treatment are the same for road accidents as for industry and much of the knowledge originally discovered in the search for the better treatment of industrial injuries has been and is being applied to general surgery . The work on burns has been of the greatest importance.

There is in London another Medical Research Council Unit known as the Department for Research in Industrial Medicine. This unit has tackled a wide variety of subjects from fluorine poisoning in Scotland, and the study of the various metal poisonings, to the study of the dangers to agricultural workers of the use of weed killers and pesticides. There is a Toxicological Research Unit which deals with both the academic problems of toxicology as they apply to the new and old poisons and with *ad hoc* problems raised in industry in the use of new substances.

At Cambridge the Industrial Psychology Research Unit carries on its work—you have already heard of the type of work that unit undertakes from Dr. Mackworth, the Director. As you know, their function is to fit the job to the man—this science has recently been given the high sounding name of Ergonomics. The Cambridge Medical Research Unit was one of the pioneers in this field.

Research is also carried out in certain University departments, often on grants from the Medical Research Council or on money provided by industry. Since industrial medical problems may cover a very wide range sometimes involving collaboration between three or four disciplines, the University is a particularly suitable setting for this type of investigation.

It may be stated emphatically that the facilities available in this country for research in industrial medicine are perfectly adequate. There are, however, two important problems which have not been completely solved, namely, how to ensure early identification of problems needing research and how to put into practice the knowledge resulting from research in the day-to-day practice of industry.

In summary, the statutory services provide for minimal standards throughout British factories, and the voluntary services provide opportunities for experiment and constitute the growing edge of industrial medicine in this country. Adequate research facilities exist for the most thorough investigation of occupational health problems.

critical survey

I now propose to examine certain aspects of these services as they are working today and where appropriate give personal views of what they might aim to achieve and how they might be modified.

medical services to the worker

As noted earlier, these include provision of casualty and first aid services, health education and medical examinations. I feel that the subject of medical examinations in industry, particularly routine examinations, deserves further consideration. From the doctor's point of view a series of routine medical examinations is apt to be wearying and to blunt his clinical skill and thus defeat the object of his work. They should, therefore, only be enforced when directed towards a clearly defined goal, possible of achievement. The problem has been discussed with characteristic wisdom by Norman (1960).

At present such examinations are carried out in various circumstances; some are statutory, some otherwise;

(*a*) before employment;
(*b*) periodic for those in jobs with a health hazard;
(*c*) young persons;
(*d*) resettlement after illness, including disabled persons;
(*e*) bad sickness record;
(*f*) senior staff and executives.

(*a*) ***before employment***: These are usually carried out for one or more of the following reasons:—

(i) to place the worker in a suitable job, either to ensure his own safety or health or to ensure that he does not prejudice the safety of others;

(ii) for admission to a Superannuation Fund—this is comparable with a Life Insurance examination, except that many firms make no provisions for the " bad life " and he may be denied otherwise suitable employment on these grounds;

(iii) for admission to a Sick Pay Scheme.

Examinations for admission to Superannuation and Sick Pay Funds are probably a matter for discussion between actuaries and doctors, but I would submit here that the matter is worthy of more than the uncritical acceptance it gets at the present time. I would suggest that general pre-placement medical examinations to ensure that the worker is to undertake a suitable job, should be confined to special groups. In particular to those on whom the safety of others depends, e.g. drivers of public transport vehicles, and those applying for work which has special risks, e.g. certain chemical workers. In France, where a national industrial health service has been introduced, pre-employment medical examinations form the basis of the scheme. I have yet to be convinced of its direct value, and do not consider such widespread and indiscriminate medical examinations as a reasonable and economic use of medical manpower.

(*b*) ***periodic medical examinations for those working in jobs where there is a health hazard***: These constitute an important group of medical examinations in industry. Sometimes they are arranged voluntarily by the employer, but often they are statutory. These statutory examinations in very many instances fall far short of good current medical practice and are, by modern standards, of comparatively little value. For example, the A.F.D. is considered by law to be supervising lead workers if they file past him—he can see the colour of their skin and perhaps ask one or two questions. Again, the Pneumoconiosis Panel supervising workers in dusty trades where they might get a fibrosis of the lung is not required to make an X-ray examination. In both these examples, modern techniques make it possible to detect early changes not apparent in a simple clinical examination, and many employers have instituted schemes of medical surveillance employing up-to-date methods. This is an area where the gap between voluntary and statutory services is wide and serious. It is necessary to provide facilities to make such control possible and to make their use compulsory.

(*c*) ***young persons***: A child is examined at least three times by the School Medical Service. If on leaving school the child (now a " young person ") enters a factory, he is examined on starting and then annually until the age of 18 or every time he moves from one factory to another.

As noted earlier in this Paper, the examination of young persons in factory employment dates back over 100 years. During 1959 nearly half a millon of these examinations were carried out; of this number 1,556 young persons were rejected, 682 for pediculosis and 322 for refractive errors. This suggests that the health of the present day child about to enter factories is satisfactory. It must be pointed out, however, that the fee paid for this statutory examination is small and the time available often does not permit of a thorough examination. It is suggested that the time has come for a critical appraisal of the value of this type of medical examination. It would seem that where the school medical service has shown a need, a child should be followed up whatever its occupation, while those children in normal health might well be subjected to fewer re-examinations.

It should be remembered, however, that the A.F.D. service does cover all British factories and whilst the statutory work of these doctors may not be realistic they are available for advice on other subjects. It has been suggested that their true value lies in this indirect service. If this is so, the sooner official duties bear a closer relationship to their useful function the better.

(*d*) ***resettlement***: In recent years it has been realised that rest in medical treatent can be overdone. Nowadays the patient is encouraged to move around the hospital ward within a day or two of having his appendix removed; the man with a fracture is encouraged to be up and about within the limits imposed by his plaster cast. Exercises are widely used and constitute an important part of treatment. It is important that this form of treatment should not be continued for extended periods in the hospital atmosphere. In those cases requiring long continued treatment of this kind it is found more effective when carried out in the working environment.

There are a few excellent examples of special provisions for this type of treatment being made by employers—the motor industry led the way in this venture. It is not possible for most firms to have such elaborate arrangements, but it is often possible so to modify a man's job that he can return to his work before he is 100% fit. This is often frowned upon by managers and foremen and one is aware of their difficulties; on the other hand it must be appreciated that there are certain cases in which such a return to work holds out the only hope of full recovery. Time and again one has seen a man slipping downhill until such arrangements have been made. I submit that with proper safeguards this type of help should be given by management.

Here the industrial doctor has to exercise his clinical skill, his knowledge of industrial processes and his ability to collaborate with his professional colleagues, who frequently do not appreciate the difficulties such cases present to industry.

(*e*) ***examination of those with bad sickness records***: The doctor in industry must keep in close touch with those whose health is indifferent, and who incur considerable sickness absence. His object will be to see that the physical and psychological aspects of the occupation are suitable. There may be a tendency in certain organisations, particularly where full payment is made during sickness, to expect the doctor to keep his eye on any abuses of sick pay schemes. This may present him with a difficult ethical problem and while he must not be expected to act as a policeman, he must be prepared to express an opinion in such a situation. In doing so he will find that he has the full support of the vast majority of the workpeople. It is not out of place to mention here that much long term sickness has a psychological origin and that while domestic conditions are more usually responsible, the work situation is sometimes the cause.

(*f*) ***senior executives***: The question of periodic examination of executives has received much attention of late. There is some reason for this on general grounds, since middle-aged men now constitute one of the most vulnerable groups of our population, a position formerly held by children.

I know of no evidence to suggest the business executive is any more vulnerable than the rest of Social Class I, but he often carries a heavy responsibility for the well-being of a business. The reason for the wish to do everything possible to safeguard his health is obvious; what is far less certain, however, is how far the routine medical examination can be of assistance. These procedures have been the subject of considerable controversy and an objective assessment is badly needed. Such an assessment is difficult and may even be impossible because the value of the medical examination is largely a function of the personalities involved—that of the patient and of the doctor. It would be easy to determine the number of abnormalities detected in such routine examinations, but how far these are important and how far their treatment is likely to affect the health and the efficiency of the executive is very problematical.

It is probable that the value of these examinations is almost entirely dependent upon the " leisurely interview " with a wise physician associated with a careful clinical examination. In these circumstances the examination itself can have a therapeutic effect and I would stress that the leisurely interview is of paramount importance. It is obvious, however, that it would be extremely difficult to make a scientific appraisal of the value of such an examination, depending as it must, on imponderables.

My own view, for what it is worth, is that when carried out on a completely voluntary basis and with a guarantee of absolute confidence, such examinations can be of value to certain individuals, but the degree to which they can make any direct impact on the general health of the executive will depend upon the educational element in the interview. It may well be, for instance, that by influencing those who direct policy the doctor can modify some of the unhealthy practices which at present affect the life of the senior executive.

environmental services

I turn now to consider the second group of functions of an Industrial Health Service—those which aim to ensure that the environment in which the work is carried out is suitable for the worker.

It is not always possible to make a job 100% safe and the whole question of " how safe " is one which is capable of considerable philosophical argument. Generally one must rely on a commonsense appraisal of the situation. The employer is concerned that his workpeople should remain healthy and efficient. This attitude may be determined by enlightened self interest, by a sense of social responsibility or a mixture of the two. He is concerned to see that the job is not too hot or too cold, that lighting is good and noise not too disturbing, that machines and processes are safe and that physical comfort and the general amenities are of a reasonable standard. Much has been done along these lines and there is little doubt that the standard of creature comfort in many of our factories today is higher than that found in the home. Minimum standards are laid down by the law and many employers have far exceeded these basic requirements.

In some industries it is necessary that environmental conditions should be measured and continue to be monitored. Such work, the function of the occupational hygienist, is particularly important where dangerous dusts, fumes, or radiations are likely to be encountered. Hitherto, a few progressive industries with their own special hazards have engaged scientifically trained personnel to work on various problems of the industrial environment, and these men have tended to remain specialists on one or two particular hazards.

Although this is satisfactory so far as it goes, the existence of problems of this type is not confined to the large firms. What is needed is an occupational hygiene service available both to the Factory Inspectorate and to private industry, with a staff capable of tackling any problem. Such a service should also be capable of undertaking the examination of biological specimens submitted by the doctor in industry, such as are often necessary in the routine supervision of workers in certain dangerous processes. This advance in the scientific assessment and control of the environment could readily be provided by setting up a few suitably sited laboratories. Experimental schemes are under consideration and it is to be hoped that they will materialise and will lead to a comprehensive service. The United Kingdom at present lags far behind both the United States and Scandinavia in this particular field.

There can, of course, be no question about the importance of ensuring an environment free from danger to physical health. Nevertheless, the work of Elton Mayo and many others, demonstrating that the provision of psychological comfort is at least as important as refined attempts to improve physical comfort, must be remembered. The problems resulting from bringing people together in large groups have been discussed by Revans, who has demonstrated the importance of the factor of size in determining

absence rate from all causes, accidents, sickness absence and unauthorised absence. Although the complicated problems of human relationships that exist in large organisations are essentially the concern of management, the doctor who spends time in industry is often in a position to detect early threats of trouble. There can be little doubt that if he is a wise physician he can provide a great deal of help for worried, anxious people whose reactions in a tense industrial unit may have far-reaching effects. This is a nebulous role and one hesitates to define it or elaborate; much depends on personalities and particular situations. It is important, of course, that the doctor should not himself provide a complication—close and easy working with personnel managers is essential but in modern industry management may well find that it is in this field of mental health that they most require medical help.

future developments.

So far I have examined the function of industrial health services and have shown how these have developed and have discussed some of their shortcomings. From their nature the more complete services tend to be confined to the larger industrial units and it is estimated that not more than half of our factory workers have the benefit of these services. Should they, therefore, be extended and, if so, how far? We should first examine the need and then consider how this might be met.

If we accept the Dale Committee's recommendations it follows that the advantages of industrial medical services should be extended. In certain types of factory and in certain processes there is a clear case for additional medical supervision, where there is a hazard the value of such a service is not in question; it is not always so easy, however, to establish the need.

Take, for instance, a small textile factory employing 100 people. How far is an industrial medical service in excess of present statutory provisions warranted here? The casualty or First Aid service should certainly be supervised, but this could be one of the duties of a visiting nurse. Return to work after serious illness could be dealt with by the manager who, with his knowledge of his workpeople and with the assistance of the patient's general practitioner, should have little difficulty in making suitable arrangements. There will be a few cases where specialist medical help would be an advantage but one doubts whether these cases would be sufficient in number to warrant the routine visits of such a doctor.

The same arguments apply to an even greater degree to the very small units of 20 or 30 employees. It would seem that the only way to deal with these small factories is by provision of more intensive inspection and adequate facilities for consultation. The possibility of using the trained industrial nurse to cover a number of small factories is attractive, but nurses are more scarce than doctors!

What of the larger of the "smaller factories"? At some stage (depending on size and nature of industry) there is likely to be sufficient need to warrant the weekly visit of a doctor trained in industrial medicine (in Norway the figure is fixed at 100). You will notice that I emphasise training; without it visits of this sort are likely to be of comparatively little value.

Following this extremely cursory appraisal of needs we can perhaps see a possible pattern for the next stage in development of our industrial health services:

1. The establishment of an occupational hygiene service backed by laboratories. This will give a better control of dangerous trades and make available, to all who care to seek it, scientific advice on the control of the physical environment.

2. A review of our A.F.D. Service, with an attempt to bring the statutory duties more into line with modern needs. The A.F.D. when properly trained might be regarded as the local specialist in industrial medical matters and might have statutory duties in all factories of a certain size and, it is to be hoped, voluntary duties in many of the smaller units. In support the Medical Inspector of Factories would act in a consulting capacity on the occupational side, while it should not be too much to ask that in each of our teaching hospitals, and particularly in those situated in industrial areas, one consulting physician should take a special interest in the diseases of occupation.

3. The strengthening of the Inspectorate, both medical and lay, by the addition of nurses who would undertake the supervision of the first treatment service throughout an area.

4. Every encouragement should be given to the establishment of voluntary services staffed by trained personnel. It is necessary to stress the importance of this voluntary expansion. Advice forced on a patient or anyone else is likely to be less effective than advice which is sought. One would like to see advice being asked for. This implies a management that is alive to its needs and with the knowledge of how to secure the help it requires.

5. Research facilities are excellent at present. The identification of problems and the transmission of results would be greatly helped by the occupational hygiene service and by a network of trained factory doctors.

6. The training of the doctors for industry would have to be carried out in our medical schools; already there are three centres in England where this training can be given.

As I see it, this is the kind of development we should aim at in the immediate future. Staff would be both whole-time and part-time; the latter, i.e. general practitioners undertaking duties in industry, would probably be far more numerous than the whole-time men. I have not suggested changes in the administrative pattern because I think these are arguable and not of great interest to my present audience. Once the factory industrial health service is on a sound basis it can be extended, with suitable modifications, to other industries. You will see that the method of advance suggested is similar to that which has been employed in the past.

In conclusion, it may be stated that by and large the statutory provisions for the health of the factory

worker are now firmly established in this country. To remain effective it is essential that these provisions are kept up to date. This means that our rapidly changing industry must be kept under lively scrutiny, so that new health problems are early recognised or even anticipated. A glance at recent reports of H.M. Chief Inspector of Factories shows appreciation in official circles of this point. It is no less important, however, to ensure that advances in technique, in medical and para-medical fields are appropriately applied to industry.

Although the doctor's part in the prescription of a healthy physical environment is largely achieved, there are still problems awaiting solution. The long-term effects of certain chemicals, the best use of the middle-aged and older worker, the changes resulting from automation, the physiological effect of shift work, modern office design, are a few of these. They will require a lot of patient and well-directed work and as these problems are solved, I have little doubt others will arise. When answers are found it will be for management to put the results into practice.

As always, however, the doctor's major role in industry is with people—individuals or groups. He has a valuable contribution to make in the full treatment of many patients of the National Health Service. Whether it be in easing return to work after serious illness or in smoothing out difficult work situations he will be working side by side with the recognised health agencies on the one hand, and with his managerial colleagues on the other. He will have achieved his proper place in industry when he is able to use both in the best interests of the patient—and in this way he can best serve industry.

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REPORT AND DISCUSSION

THE 1960 Sir Alfred Herbert Paper entitled "The Doctor in Industry" was presented by Professor Ronald E. Lane, C.B.E., M.D.(Lond.), M.Sc.(Manchester), F.R.C.P., F.R.S.H.(Hon.), D.I.H. (Hon.), to The Institution of Production Engineers at The Royal Institution, Albemarle Street, London, W.1, on Thursday, 10th November, at 6.30 p.m. The President, **Mr. G. Ronald Pryor,** occupied the Chair.

The **Chairman,** in opening the meeting, said:

"First of all, I should like to thank The Royal Institution for making this delightful theatre available to us. There is a tradition here, of course, that adds greatly to any meetings which are held here, and the Council of The Royal Institution are always very kind in making it available to our Institution. I feel I should convey to them on your behalf our great sorrow at the loss of Sir Harold Spencer Jones last Thursday. It was a great shock to us all. He was the Institution's guest at the dinner at the Dorchester on Wednesday night and apparently in robust health, but the next day was the end.

"This is the ninth Sir Alfred Herbert Paper, and the Sir Alfred Herbert Paper was the first of the Named Papers of the Institution inaugurated to honour men who had given outstanding service to the Institution. Sir Alfred expressed the desire that the Papers given under his name should not be confined to the narrow field of metal working.

"First of all, we had 'The Development of Engineering Metallurgy' by Dr. Rolt. Then we had 'Industrial Applications of Radio-Active Materials' by Sir John Cockcroft; 'Problems of Higher Technological Education' by Lord Halsbury; 'Work Design and Attainment for Future Industrial Skills' by Dr. Mackworth, which was perhaps the nearest to our subject tonight; 'The Development of Technological Education in Europe, America and England' by Dr. B. V. Bowden; 'The Bases of Measurement' by Dr. H. Barrell; 'The European Common Market' by our Past President, the late Sir Cecil Weir; and, last year, 'Recent Production Developments in the Soviet Union' by Dr. Galloway, following his recent visit.

"Now we have Professor Lane, and we are very fortunate to get him, because as well as having a wide knowledge of problems in industry, he also has a very wide experience outside. He occupies the Nuffield Chair of Occupational Health in the University of Manchester and, as well as various appointments of that sort, he is a Lecturer at the Royal College of Physicians.

"I have much pleasure in introducing to you Professor Lane."

Professor Lane, presenting the Paper which appears on pages 1 - 8, said:

"I would first like to thank you very much indeed for the great honour you do me in inviting me to give this lecture. I realise the responsibility you have

placed upon me, and having just listened to your list of former lecturers, I feel not a little frightened.

"My lecture has been published and I propose to take it as read. In it, I have tried to outline the present situation of our medical service in industry, to offer some criticism and perhaps to point a few ways we might go in the future.

"Doctors must be interested in people's occupations, if they are to diagnose accurately and treat successfully. The first physician to emphasise this was an Italian called Ramazzini. Ramazzini was a well-known and great Italian physician of the 17th century and it was he who really emphasised the importance of the occupation of his patients. He taught his students that to the list of questions they were asking, they must ask 'one interrogation more, what trade is he of?' and this is what we teach our students now.

"About 150 years ago, here in this country, in Leeds, we had another physician, Charles Turner Thackrah. He, too, was very interested in people's occupations, but he went further. He was interested not only in the diseases that various workers suffered from, but he was interested in their prevention. Unfortunately, he died at the early age of 38.

"He wrote about 250 different trades. He in fact was interested in all sorts and conditions of people. He was interested in what I suppose was the equivalent at that time of a production engineer. He talks about them in this way: he says 'He lives in a state of unnatural excitement, his nervous system worn out by excess of action. You can identify him by his hurried gait and care-worn features.' He went on to talk about other people. Compare this with what he had to say about the 'sales type'. He says: 'The salesmen are well-fed, riding from town to town. They have an employment not only more agreeable but more conducive to health but they destroy their constitution by daily taking more liquid than nature requires.'.

"Thackrah was the first of a long line of doctors interested in occupation, interested in industrial medicine, and tonight I want to talk about just this sort of doctor. This sort of man knows industry at first-hand; he is interested in its materials, its methods, its staff structure and its personalities.

the doctor as a part of industry

"In order to achieve this, the doctor must be invited inside; he must be a part of industry, and what I want tonight is your reaction to this idea. As a doctor, I see the need and the place for just this sort of doctor, but I want to be sure that those of us who have this idea are not 'going it alone'. Medicine cannot make its proper contribution in this field if its dicta are decorously murmured from ivory towers. We must be in industry; and we want to get you people deeply interested in our sort of ideas and problems. I realise, of course, that an industry prospers because of its efficiency. My thesis is that we also have a contribution to make to this efficiency. After all, production comes from people. Let me make my position quite clear: we are interested in people. This is our job and this is our stock-in-trade. We are very pleased if, as a by-product of our activities, your production is improved but this is not the doctor's first aim. Our contribution is, we hope, to the public health, and I say this in all humility, because I know how small our part is as doctors in furthering health.

"I remember only too well the depression of the thirties when people were without jobs, were ill-fed, and the rest of it. I realise only too well that industry has far greater powers to influence health than any doctor. I teach this to my students in an attempt to get them to see things in perspective. I tell them that health is related to three 'E's'. You must bear with me in this kindergarten approach; I hesitate to use it in these portals but I do want to make this point. What do I call the three 'E's'? Of course, you will realise the first is for economies: enough food, decent shelter, a reasonable standard of living, and this depends on money. It depends on the prosperity of industry. The second 'E' is education: it is essential in this modern society of ours if people are going to get the best out of life and are going to be able to live a healthy life—here the doctor has a role. What about the third 'E'? Equanimity: I think industry's influence upon peace of mind can be enormous: security, a definition of responsibility, knowledge of 'what is cooking'. It is important for people that communications should be good.

the management contribution

"That is the sort of contribution that industry can make, that sound management can make. It is management's contribution to health which really far outweighs the sort of thing we do. So much by way of introduction.

"But what of the doctor? What can he do? We train as doctors to treat sickness and to prevent disease. These are the functions of the doctor, wherever he is working. If he is working in the National Health Service, he is treating sickness and doing his best to prevent disease. These too are his functions in industry, where he is still concerned with treating sickness and preventing disease in a special setting — still concerned with people. I have said production comes from people — no one knows this better than you do. You have your job in industry because of your skill with people, your skill in picking them, and your skill at handling them, and you will therefore not underestimate their importance. You will be ready I hope to accept technical help with them, and this is the sort of thing that we hope we can sometimes do.

"In my Paper, I have tried to show this. This is not a new conception, of course, by any means. I hold here in my hand one of the day-books of a doctor in a medical service that was functioning in industry 170 years ago. I read from it: 'Date: March 28, 1807' — long before Waterloo — 'Sarah Elinor: let her shoulder be raised from the body by a pillow fixed under the arm, and let the arm be kept at least half a day in this position. Let the ointment be discontinued.' The book is full of this sort of thing.

He was working for a little cotton mill. So the employment of doctors in industry is not new. It has been going on for generations; it resulted from the attitude of enlightened management. Human nature being what it is, this was not the attitude of all employers and health had to be safeguarded by legislation. Over the last 150 years, this legislation has been built up in our Factories Acts.

" I have referred to this in my Paper. I propose only to talk about factories this evening because it seems to me that this is where your interest lies.

no organised service

"I have spoken about an industrial medical service : actually, of course, there is no fully organised industrial medical service. It is quite distinct from the National Health Service — nothing to do with it. You may regard this as untidy. Perhaps it is administratively untidy. Should this be changed? I do not know; I am not prepared to suggest that it should because I think the present method has great advantages. You may want to argue this. The Factories Acts lay down minimum standards — minimum standards for the environment, clean premises, safe plant and processes, minimum standards of medical care. Children have to be examined and so on. To see that this is done is the responsibility of management, just as much as meeting the urgent demands of a sales department; but, of course, there is no sales manager at the other end of the telephone to prod you and ginger you up.

" The Factory Inspector comes along occasionally. You may know when he is coming and get things nicely ' dolled up ' for him. This is the sort of human reaction we know. The urgency of production may put everything else out of your mind. You may be prodded by the shop stewards or works committee, but pressure of this sort may often, be quite uninformed. You know the sort of thing that happens. You put in a new process; people start getting dermatitis, they go and get treated somewhere in the works but you are not informed. Cases go on occurring and suddenly, out of the blue, you do not understand why, you have a strike on your hands. This would not have happened if your casualty department had been properly staffed and properly trained. If so you would have been advised, and you would have had someone there to prod you and help you. That, of course, is the reason why many factory managements have gone beyond the strict requirements of the Factories Acts and have engaged voluntarily doctors and nurses.

" My entrance into industry was in just this sort of way. In the late twenties, the accumulator industry was being troubled by lead poisoning. The Factory Department introduced a code of regulations which was based on the most up-to-date practice of the time, which was that used in this large factory. But despite the introduction of these regulations — because the industry was expanding so quickly — the incidence of cases of lead poisoning went on rising, and at that stage, management decided that something must be done and a medical service was started. As a result it was possible to improve conditions very much, to work out what was a safe limit to the amount of lead allowed in the atmosphere; and having worked this out, to hand this prescription to the engineers. It was for them to dispense this prescription, which they did, and later, the experience of this factory in so far as lead poisoning was concerned has been a very happy one.

" We were fortunate in having a method to enable us to assess objectively the amount of lead absorption taking place, because changes occur in the blood. (Fig. 1.) It is possible by examining the blood in this way and actually counting the number of stippled cells to make an assessment of the degree of absorption that is going on.

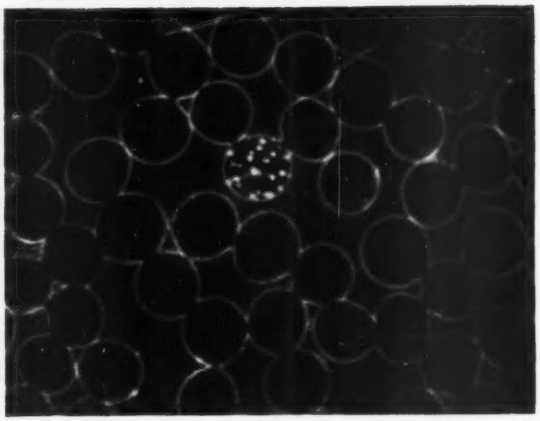

Fig. 1.

" There have been a large number of notable examples in which doctors have been engaged to deal with a specific hazard of this sort over the last 25 years. The Government has recently declared that its policy for the immediate future is to urge an extension of this sort of service on a voluntary basis.

" This is important because it does represent a ' growing edge ' of industrial medicine. Those are the circumstances under which experiments can be made.

" I have referred in my Paper to the functions of medicine in industry. First, of course, it must provide a thoroughly efficient treatment service. But there are other, and probably more important, functions. I have classified these in two groups : those functions which ensure that the worker is fit for his job, and those which ensure that the job is suitable for the worker.

" In my Paper, I have discussed, for example, medical examinations. I have pointed out that I am opposed to general pre-employment medical examination. I do not think the return is adequate and I am certain they are not worth the effort.

" There are certain groups, however, which should be examined before starting work, because perhaps their work involves the safety of other people. You would not like to be driven by an epileptic bus driver. There are also dangerous trades. It is certainly an advantage to examine people before they engage on dangerous work. In these circumstances, the examination must be carefully devised and it must be adequate for the job it is intended to do.

" I do not believe at the present time, for instance, that the examination of children in our factories need be done anything like as frequently as it is. I am speaking as an individual, and I am just expressing my own personal opinion. It seems to me that we could use the time of properly trained factory doctors to better advantage.

an important examination

" I do think that one of the most important medical examinations is that carried out on the return to work. In this situation, the doctor in industry is co-operating on the one hand with the hospital and the general practitioner, and on the other, with his colleagues in industry, and this is a very important function. It is not infrequent, by any means, that a patient's full return to health is utterly dependent on his being handled correctly just at this very critical stage.

" May I quote you a case? This was a young man who was referred to my clinic not long ago by the Ministry of Labour for registration as a disabled person. He was 27 years old, recently married. He had had a foreign body in his left eye while working in a foundry. He was treated in the hospital and, at the end of three months, his vision in one eye was perfectly good and, in the other, had returned to 50% of normal. The patient when he appeared in my clinic had a patch over his left eye. He was complaining of constant headache, loss of appetite, inability to concentrate and dizzy spells. This from a young man who had a very good service record and hitherto an excellent work record. He had been married a year; his wife was working, and he was working overtime in order to get a home together. As a result of this illness, and this accident, not only had he not worked but in view of his later symptoms, his wife had given up her work as well and was looking after him. Both wages had stopped.

" Obviously, when we saw him, he was in a nervous, anxious condition, and our job was to see how we could restore him to reasonable health. We got the report of the eye surgeon who reported still further improvement. In order to achieve our object, we arranged a meeting between the man, his wife, the eye surgeon, the rehabilitation officer and myself. We had a ceremonial destruction of the eye patch and we then assured him most emphatically that the eye was all right and that he was going to be able to work normally. We refused point blank to regard him as a disabled person. Success depended on being able to demonstrate to him the truth of what we said. We were able to get his employer to take him back; this was the essential step, this gave him confidence. He spent the first few weeks on a job we thought would toughen him up a bit, and at the end of a month, he was back in the foundry earning a normal wage. This was the only way this man's treatment could succeed — with the co-operation of industry.

" In my Paper, I have discussed the second group of functions, in regard to which a very great deal is laid down in legislation. Dangerous processes have to be carried out in a way which is safe. We should be able to assess the various noxious toxic agents, harmful dusts and gases should be kept below a dangerous level. In order to do this, we must be able to measure them. In recent years, we have had an excellent example set us by the Atomic Energy Authority. Here there is a potential danger from ionising radiations. It is recognised and a safe dose has been worked out and agreed. Premises and processes are designed in view of this data. The process is constantly monitored and the dose of each worker is measured and recorded. This is an ideal method. It is possible to do it with great accuracy in relation to ionising radiations, but it is possible to use the same principle in many other industries, If we are going to do so, however, we must have laboratories, and we must have staff available to carry out this sort of measurement. It is very good to know that plans are on foot and have recently been announced in the House that this is one of the projects in mind for the use of the Nuffield quarter of a million to be used in this field.

the value of research

" Finally, a word about research. I have said in my Paper that we are very well placed as regards research in this country. Much is done by the Medical Research Council; its teams have tackled the main problems, the treatment of industrial injuries, the dust diseases, etc. The Universities also do a considerable amount of work in this field, and they are well placed to do so because, research in industrial medicine often involves a number of disciplines. It may be the chemists, the physicists, the engineers, the physiologists, the psychologists, the doctors — all the lot. It is easy in a medical school to call on the various experts. I will tell you briefly about one example of this sort from my own department.

" In Lancashire, in the cotton industry we have a chest disease which has been known for over 100 years. After years of employment in the Card Room, many workers develop byssinosis — a lung disease which leaves the patient very short of breath. He may find getting about difficult and in the late fifties he may be able to do little but sit about. This is the sort of fate that has met not a few people in this industry. Although they lived in the same houses, had the same sort of wage packets and suffered the same sort of atmospheric pollution and the rest of it, there was a great difference in the mortality rates from chest diseases between those working in the dusty part of industry and those working in the clean part of the industry. Those in the dusty part were dying earlier and in greater numbers of respiratory diseases (Fig. 2). Here then was the long history and here

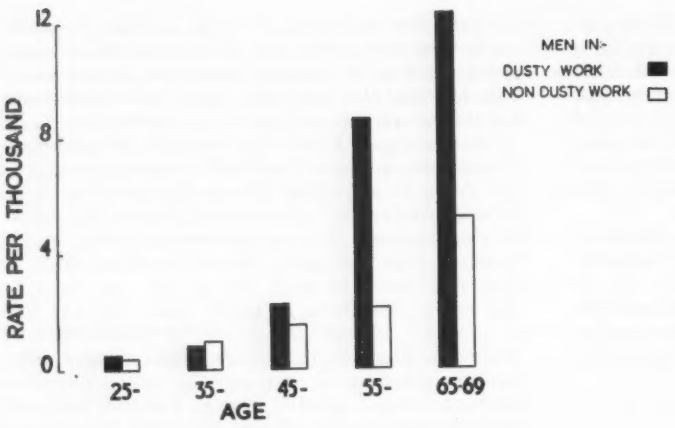

Fig. 2. Deaths from respiratory disease among cotton workers, 1930 - 1932.

are the factual data which confirmed this. Dr. Schilling, who was working in my department at that time (and who has recently been appointed to a Chair in London) with other members from my department, worked on this subject. This particular disease cannot be diagnosed by changes in the chest X-ray because there is none, and it was necessary to find some other objective measure of the presence of this disease. A method was devised for this, (Fig. 3) and the impairment of breathing among normal men as they get older and among affected Card Room workers is clear. The dust is produced particularly in the carding process and the nature of this dust has been carefully investigated by bacteriologists and pharmacologists.

"It was also necessary to see the extent of this disease and we looked outside the cotton spinning industry. We looked at the waste cotton industry and we found the disease existed here. As a result of this work the arrangements for compensation were changed, and people working in this particular part of the industry are now able to get compensation for the disease.

"This is not, of course, the real object of our exercise. The real object is to prevent the disease, and here again, we as doctors cannot do very much. We get the help of the engineer. A Shirley device is fitted to a carding engine in order to apply suction at particular points (Fig. 4). The engineers have been able to devise this apparatus which makes it possible to keep the Card Room almost dust-free, while not creating difficult heating and humidifying problems. This is just the sort of thing that can be done and is done in the research field, in this case, in a University and an industrial research institute.

"It is easy to get research done on a good problem. The difficulty is sometimes to identify the problem. Then having identified it and having done the

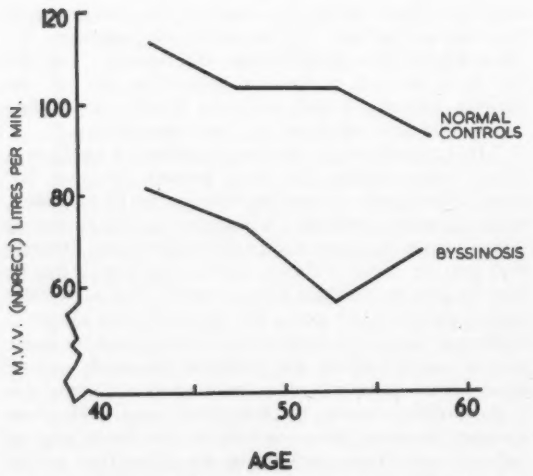

Fig. 3. Maximum voluntary ventilation (indirect) of men with byssinosis and controls.

Fig. 4. Carding engine fitted with Shirley device to suppress dust.

research, the much more difficult job is to get results accepted in industry; and this, of course, is where you come in and this is where the doctor in industry comes in, because it is his job to keep in touch with what is going on in the research field and to keep you informed of results; and it is for you then, not for him — he is merely an adviser — to see what can be done about it. It is your interest and your support that is so important. This is one of the most important functions of the doctor in industry, to produce a link between those discovering new knowledge and those who can apply it. There are other problems awaiting research at the present time — many of them — those relating to the middle-aged and older worker, for instance, are very important in modern industry.

"These then are some of the functions of medicine in industry. Some are humdrum; some involve high powered research; but let us face it, the man who probably does most for industry is the chap who establishes himself in an organisation, is known as a good doctor and as a sound and fair man. He is available for consultation about works problems to the labourer or to the senior executive alike. If such a man can bring to one of our large mechanised organisations which modern industrial civilisation is producing, something of the medical ethic, the feeling of the importance of the individual, he will not be wasting his time and I think he will be doing a good turn."

Mr. W. Core (*Director, Alfred Herbert Ltd.*), opening the discussion, said that although he was not qualified to discuss in detail the wide and important survey presented by Professor Lane, he would like briefly to recall the great interest taken by the late Sir Alfred Herbert in the welfare of health and accident prevention which was the joint responsibility of management and worker.

As the Chairman had mentioned earlier, Sir Alfred Herbert had asked that subjects chosen for his Paper should not always lie within the purely technical field and the choice that night was a very good indication of a subject of equal importance to everyday maintained production.

The outlook on safety regulations and concern for the worker's health had altered radically during the present century, and it was gratifying to know that the hazards of factory life — to which comparative indifference was once shown — was now recognised as a *must* throughout industry today. From the more complete guarding of machine tools to medical consideration towards grinding operators with silicosis and other respiratory diseases, they had emerged to a realisation that smoke, ventilation, lighting, heating and cleanliness were all related to the wellbeing of the worker and, in consequence, of the nation. In Mr. Core's own company, they employed a doctor who attended for two hours daily, with full-time nursing staff and surgery.

A point to which they gave attention, which might be of passing interest, was the importance of giving all crane drivers a strict eyesight test, for what might be termed his three-dimensional duties in judging length, width and depth in working the crane.

Mr. Core had been very interested to hear recently from an executive of a large organisation that they employed three full-time doctors and dentists, and that an incentive was given to departments in the form of a monetary bonus when 400,000 accident-free hours had been achieved. That was based on a 40-hour week, with the total number of employees being calculated to give so many weeks of absenteeism due to accidents when work hours had been lost.

He hoped that his layman's brief outline might form the basis of discussion for members of the audience better acquainted with the subject than himself.

Mr. L. E. Glover (*Woolwich Polytechnic*) asked whether Professor Lane would expand further his brief comment on the value of a medical service in industry, in that it could give valuable advice on the use of the older worker in industry. That would, he thought, seem not necessarily to rely so much upon the presence of a doctor in a factory, as upon external research findings which could be used as a general measure for the guidance of people towards the better utilisation of the older worker.

Professor Lane said that he was glad that point had been raised. He thought that this was one of the most important pieces of information required at present. The Medical Research Council had a team working on the subject at Liverpool, and Dr. Heron directed that unit. Dr. Heron had told him that he felt that one of the points which seemed to militate against a real fundamental understanding of that problem was the innate kindness of employers to their older employee. They were prepared to let him go on as long as he could keep up; as soon as he could not keep up, they would push him out of the main stream usually into some shop where the conditions were often indifferent and, eventually, he would have to pack up.

The thing that worried older people, of course, was speed, not physical effort. Many men of 70 could undertake quite strenuous physical effort, but many men of 50 could not keep up the racket of modern production. It would be noticed he had spoken of the middle-aged as well as the older worker, and the point Dr. Heron stressed was that the problem should be faced not when a man was in his sixties or late fifties, but in his middle age. Processes and training methods must be investigated with a view to transferring him to work for which he had been trained but which did not make such demands on him; in other words, was not so fast. If that were done, it seemed to him that they should be able to use workers effectively and efficiently and profitably very much longer than was possible at the present time.

One of Mr. Heron's points was that some of the older worker's wives had told him of their anxiety at seeing their husbands struggling to "keep up" with their younger work mates and of the fatigue and stress this produced.

Dr. W. S. Hollis (*Assistant Director, Ministry of Aviation*) said that two points occurred to him. In the first place, it was not so very long since the engineer had called in a metallurgist when introducing a new method. Previously he had been quite satisfied to cut metal, weld it, or form it and learn by the various patterns of failure. So the introduction of metallurgy had been a step in the progress of production technology but it seemed that very little had been done in introducing the medical field to the consideration of health hazards arising from new techniques.

In that connection, the introduction of carbon tetrachloride, as a cutting agent, produced noxious fumes and there was some suggestion of phosgene gas poisoning if one was smoking in the presence of the vapour. Considerable risks could be taken mentally or physically on the introduction of new methods to the workshop and changes should be effected in conjunction with medical services.

The other point was that Professor Lane had described several industrial diseases, and those had all been of a physical character. Had any approach been made with regard to the mental state of the operative? There was, for example, begining to be an interest in ergonomics — the study of the manipulating of machines, and the mental and physical attitude of the man who worked them; but apart from any physical relaxation that might be obtained in that study, it seemed that much more consideration would have to be given to mental fatigue in working the complex machine. Manipulative skills would soon be replaced by the machine operating with numerical control and the health hazards would relate to being geared to protracted thinking.

Professor Lane said that he agreed that they would very much like the closest possible co-operation, particularly on new processes. It seemed to him that it was rather better, before designing a process, to know what sort of hazards one would be confronted with. The joint approach of the doctor and engineer or chemist seemed to him the right one. One only hoped that the doctor who was in industry was given that opportunity and that, of course, depended on the outlook of management.

If management were alive to those problems, the doctor would be only too pleased to find out everything he could about a new substance. So often, he went round and found something was going on and he had no idea it had been put in. It might well be that something was being used which was dangerous. Had it been discussed in the early stages, a simple alternative could have been used and all the difficulties could have been avoided. It was most important that Dr. Hollis's point was taken, and taken by management.

Dr. Hollis pointed out that that would save a lot of money.

Professor Lane said he was glad the mental point had been raised, because he was quite certain that the biggest contribution that the doctor made today was in the field of mental health. In the small undertaking, the relationship between workman and boss was simple. He might be an absolute so-and-so but it was a human relationship which the workman could understand. But in a big impersonal organisation, like many of the modern industries, the relationship was not one that people could easily appreciate, and this was one reason why so much mental stress existed. It was to that particular field that he was referring in the last few sentences — the humanising influence of the doctor was one of the most important contributions he could make.

Mr. A. R. Cooper (*Central Electricity Generating Board*) said that he had not intended to speak; but he had been so familiar with Professor Lane's work for many years that he was glad to have the opportunity of paying it a tribute.

It had often struck him that the impact of the industrial medical officer was both direct and indirect. The direct impact was obvious. He tried to prevent trouble by seeking out root causes and to cure ailments when they arose. But the indirect impact was also very significant. It was very easy to regard an industrial medical officer as a sort of high grade mechanic who was keeping human mechanisms in good working order in order that they would give a better performance over a longer period. But the medical officer did help management to realise that employees were also people, and it was becoming increasingly easy to forget this sort of thing in the pursuit of higher efficiencies.

In his experience, one of the greatest causes of real ill-health was not any of the obvious things like broken arms and legs, or even poisonings and the like. These cases evoked sympathy and a good deal of understanding, but the anxiety neuroses that could quietly destroy individuals without showing on the surface, were not always so fully appreciated.

Those were matters which could not be tackled except by men of understanding in both the medical and the management fields. Fears associated with the insecurity of employment, the anxieties of the man who was wondering whether or not he was going to be promoted, whether he should accept a job that was probably two sizes too big for him, when nobody was at hand to tell him he would be happier and healthier if he did not apply.

In that field the medical officer above all people could provide the understanding confidentiality which the man could not always get from a boss who was embroiled in the business of production. It was certainly better if the boss had this understanding as well, but the medical officer could be the common link. His status inside the industry was never sharply defined. He was the confidant of the labourer but also the confidant of the managing director, and he could perform a tremendous service in improving the relationships between people, which made all the difference between working happily and consequently very much more healthily, than by any other contribution he could possibly imagine. (*Applause.*)

Professor Lane thanked Mr. Cooper for saying that, as a manager, so much better than he could say it himself.

Mr. C. F. Rose (*British Railways*) said that Professor Lane had rightly quoted the value of a doctor being sympathetically interested in the case of a man returning after sickness or accident. Most people in industry realised that the man on light work, whether he was temporary or permanent, because he was something of an embarrassment to shop supervision, tended to become one of a forgotten group of personnel in the industrial field. To what extent did Professor Lane consider that there was work for the qualified occupational therapist to bring those men back to more effective working?

Professor Lane said that the "occupational therapist" as he used it, was a different sort of body. As he understood the term—and he might be wrong — the occupational therapist was the sort of person who worked in the hospital service and tried, by giving occupation in the very early stages of convalescence, to give some diversion and so help treatment. He felt that it was not an occupational therapist that was needed but a sympathetic foreman, a sympathetic charge-hand: the person who was going to say "I don't mind this chap coming back, I'll see he's carefully handled for a month but at the end of that time I shall expect him to do his full job." That was the proper and human way of approaching the problem.

He agreed that, so often, what happened was that those people drifted back and were completely forgotten, and got into the state in which they did not want to do anything but light work, or whatever it might be.

The return to work was important. The real man who mattered was somebody in the management hierarchy, whether it was the personnel officer, the manager, or the foreman. The foreman was the best occupational therapist.

In the few large firms, where special arrangements were made for using modifications of standard machines in such a way that their operation provided a set of movements likely to assist in the treatment of a damaged or diseased limb, special skilled help would be required and here the trained occupational therapist would certainly be needed.

Mr. H. Stafford (*United Steel Companies*) said that whether the works medical department was attending to a serious industrial injury or the massaging of the general manager's rheumatism, it was too often looked upon as an overhead charge — something which did not add to the profits and was not very popular with the accountants. But it could operate in a very practical way. A service could be given to the company which was not always realised, and he could give two actual examples.

He had been faced, not very long ago, with finding evidence to support the need for doing a complete test of every hammer that was used. Thousands of hammers were used in a large works and the decision was between whether every hammer head should be tested for hardness and cracks, or whether samples should be taken.

The only department which could produce the evidence was the works medical department, and they could provide him with facts and figures, number of cases treated, accidents arising from use of hammers, foreign bodies in the eye, foreign bodies in other parts of the body — chapter and verse. That was the only place he could get it from; there was no other source than the works medical department.

Another example was given by the rehabilitation section where he found that they were making leather safety gloves with adaptations of existing machinery, to give the type of movement required either with the hand or foot. Not only could they make them as a rehabilitation exercise, but they could make them competitively with outside suppliers. Economically, they were pulling their weight, but even more to the point, the men in that section could see that they were making something useful to their own works. Professor Lane would probably observe that that was psychologically a good thing.

Dr. Waite (*General Practitioner and part-time Medical Officer at Vickers*) asked to what extent the factory doctor should advise and carry out, say, the more common practices of general practice to the people employed in the factory? He raised that point because he found that there was a totally different attitude exhibited to him by his patients in general practice and the people who had to see him in the factory. They were always unduly suspicious and with any recommendation he made, they always wanted to know what the management was going to get out of it. After that, he had tried to introduce a scheme of re-examining every man who had been ill for more than three weeks before he went back to his job. He did not know whether he was treading on thin ice, but the shop stewards had said there were a lot of anomalies about. He had never found out what the anomalies were, but he did not get the scheme through. They thought the man's return to work might be prejudiced and he might lose money and so on.

His reason for quoting that was because he felt that if a general practitioner like himself was employed in a factory, and was giving more of a total service in an advisory capacity and probably a little more therapeutic capacity, he might gain the confidence of the people in the factory more, and any recommendations he made for safety and the advances to the men's health would be more satisfactory.

Professor Lane said that a very difficult problem had been raised. They were not allowed, and not encouraged, and nor would it be right for them, to take on the job of the patient's general practitioner. After all, the relationship between the man and his own doctor had to be maintained; but this did not mean that no treatment was going on in the factory.

Surely, a great deal of treatment of minor injuries and minor conditions occurred in the factory. He took it that the speaker was a part-time doctor in industry, and perhaps did not spend a great deal of time in the factory; and it might well be that he had not been there very long. But he did think that the relationship that really mattered in industry was that the doctor should be absolutely trusted. When he was, by length of service (which was one of the most important things) and by what people knew of him, completely accepted as an honest chap who was out to look after the workmen and not on management's side, then he would not have that difficulty. Most managements appreciated that. Most managements knew the doctor could serve them best if the men felt that, while he was in a neutral position, he was just leaning over on their side. That was the position the doctor should have, and in that position he could be of most value to industry.

But he understood the difficulty and they had all had it. Some general practitioner colleagues would be only too pleased if he did some work for them in the factory and this he would do by offering facilities the general practitioner could use. Others would not have him touch their patients for anything, and those he would be careful to avoid. That was one of the snags and difficulties of the practice of medicine in industry.

Mr. J. D. Lane (*Lehmann, Archer & Lane Ltd.*) referred to the question of periodic examination and asked if Professor Lane would say that the industrial doctors were moving from the position where young people where medically examined annually to the position where the older people were examined, both mentally and physically, every five years?

Professor Lane, in reply, thought that was a difficult question. It was quite true that the dangerous age group had shifted. It was no longer the children; the dangerous age group was the middle-aged man. That was the group in which the improvement in mortality rates had almost ceased. With the rest of the age groups, there had been, during the century, a steady improvement in health as measured by the mortality rate, and that applied particularly to children and young people. That did not apply to the middle-aged man and that was largely due to a group of diseases — the most important were lung cancer and coronary disease — both of which were new and both of which had been hitting that particular age group.

If one was referring merely to all men of 50 and asking whether they should be examined every five years, that might be of interest to certain people. He doubted whether one would get much out of it; people aged at such different times. It could not be said that one man of 50 was in the same state as all other men of 50. The calendar age and the biological age did not match up, so it would be very difficult to legislate for anything of that sort. With children, it had been easy to legislate; but to legislate in medical examination at the other end of the age scale, would, he thought, be extremely difficult. It would be difficult to know whether it would be profitable, but it would be very worthwhile doing an experiment. It was the sort of thing that voluntary industrial medical services might well do and if it were shown that it was a useful exercise that it should be done more widely; legislation might eventually be introduced to require it, that was usually the sequence.

First of all, it had to be demonstrated in voluntary services, and having been demonstrated many times and very emphatically, then it might be put into legislation.

Mr. Lane said he was not thinking particularly of executives, but of maintaining the usefulness of Charlie, old Joe and others in the shop. If medical experts working on behalf of the company could suggest to Charlie, at the age of 35, that because of his physical condition " It is advisable that you should start to take things more easily ", instead of waiting until 45, when he himself would realise that he must take things more easily because of the run-down of his body, were they not going to save skilled and useful men for the benefit of their organisation and industry as a whole? They would be intercepting medically the run-down of the human body; would a useful function be performed in that way? He agreed with Professor Lane that people did not age at the same rate.

Professor Lane said that the point raised was a most fascinating one. It was very much in line with the whole problem of ageing. The process of ageing started as soon as anyone was born. One was too old to fly a fighting aircraft in the late 20's and too old to fly bombers at 40. In the middle 40's, one was too old to do some of those very fast jobs found in industry. At any rate, many people were. He would very much like to know how those chaps could be picked up. The doctor in industry might have a very shrewd idea of the people who were under stress; some would ask to be taken off those jobs in their 40's. They would say " I cannot stand it; I'd rather take a smaller wage and do something else." And some would begin to lose a lot of time from minor sickness. But many people who had big H.P. accounts would not do it, and they drove themselves.

But he wondered how much more a doctor could do than a really interested manager. Perhaps he could help, but he would very much like that sort of problem to be put in the hands of the industrial psychologist. Dr. Heron, of the Medical Research Council, was working on that very problem. "At what age and how can these men be identified?" Their present techniques could not easily do so. Some techniques must be devised for picking out those people. It was not just examining them by traditional methods; new methods must be worked out and then it had to be decided what was going to be done about it. It was all very well to have a whole bundle of people on your hands, but how were you going to deal with them? How were they going on earning a decent wage?

How were you going to maintain your output and their status? Those were problems which were management problems, but he welcomed the appreciation that they arose in the 40's and not at 60, and that it was a problem for research between doctors, physiologists, psychologists and the rest. What the answer would be, he did not know, but he welcomed very much the attitude of enquiry.

Dr. H. B. Wright (*Director of Medical Research Unit, Institute of Directors*) said that there was a relevant point on the question of ageing which had not been made overtly. That was brought out by Welford and his group, working on parallel lines to Heron. It was the fact that, very often, it was possible to keep people on relatively the same work for considerably longer if the work was altered slightly, in certain respects, to make it more possible for older people to do it. The important thing was that the work should be altered before they were too old. That was a way in which doctors, psychologists and ergonomists could get together. Quite often very minor alterations, in the way of assembly and that sort of thing, helped people to keep up for a very longer time. It was a job they could all get together to study usefully and profitably.

Mr. F. W. Cooper (*Education Officer, Institution of Production Engineers*) said he wished to speak on the damage to hearing by persistent and excessive noise. When he was in engineering he had had the job of making the loudest noise in the world and listening to the infernal instrument from but a few feet away, and this had given him a lasting respect for noise.

He found startling contrasts in industry. Whereas the Electricity Authority used great skill and determination to quieten down a turbine house for the half-dozen or so men therein, heavy industry with thousands of workers appeared to make no effort whatsoever to decrease its noise. He had yet to visit a factory where periodic tests for hearing defects were conducted with middle-aged and elderly workers.

Professor Lane said the problem was an extremely difficult one, because people lost their hearing just as they lost their sight as they got older, and it was not always easy to assess hearing in a group of workpeople. He did think that much more attention would have to be paid to noise in this country. Of course, in the States, that was happening because of claims for compensation. In this country this was not the case. It might be that if the compensation laws were changed, it would be added incentive for some people to put their houses in order. It was not the right one, he agreed, but it might well be that that was the sort of thing that would happen. He agreed entirely that the question of deafness as a result of excessive noise was one which had not received enough attention in the past.

Dr. W. F. Floyd (*Department of Ergonomics, Loughborough Technical College*) said that he wanted to take the discussion back to the previous stage before noise had been spoken about. He thought that when a man reached the stage where he was unable to do a job because of, say, ageing and failing abilities, there was another solution of the problem. It was the solution which called in the engineer to re-design the job. Dr. Wright had touched on that briefly and had referred to Welford's study in that field. It was a field in which the industrial psychologist, the physiologist and the industrial doctor could play an important part in a broad industrial service, not only, as Professor Lane had already indicated in his Paper, by dealing with the situation as they found it, but by advising engineers when new processes and new systems were being developed. This was not just a new solvent, or a small thing, but something quite big, advising them on the abilities of human beings so that the new system was devised especially within those capabilities, with the capabilities of the young man built into it as well. He thought with the increasing knowledge that was becoming available, it ought to be possible. He envisaged it, and asked Professor Lane if he would agree that it was partly a job for the industrial doctor (not for the part-time doctor, but purely for the man who spent all his time in industry) at least to guide management as to where they might get the advice from the research people on problems of that sort.

Dr. Sibyl Horner, C.B.E. (*H.M. Senior Medical Inspector of Factories* (*Ministry of Labour*)) said how much she had enjoyed Professor Lane's address; she would like to say a few words about "equanimity" because it was of such importance. About a year ago, she had attended a joint I.L.O./W.H.O. conference in the United Kingdom, and the members — a mixture of physicians from industry with representatives of employers and workers — were drawn from a large number of countries including Soviet Russia.

The conference had for discussion "The Contribution of the Industrial Medical Officer to the Psycho-Social Environment in Industry". This was a formidable subject, and as might be expected among so many nationals gathered together, many for the first time, the atmosphere was a little chilly at first. However, during the 10 days they spent together the situation changed and it was clear that the experts were exercising their skills on "Equanimity". It was an eye-opener to her, although she had spent something like 36 years in industry, to learn what the industrial medical officer could do, and was doing, to give a man at work equanimity —by setting about to solve some of the problems which beset the individual and workers as a group. The United Kingdom was quite well represented but so were the other countries; we were no better or more forward-looking than some of what might be considered the smaller, less welfare-state-minded countries. How was this influence towards equanimity in industry brought about? She did not think it was brought about right away by the doctor examining and having talks with the worker.

Professor Lane (right) receiving a silver muffineer from the President of the Institution, Mr. G. Ronald Pryor.

There was a stage before that. The doctor had to get himself well-known and accepted by the workers. He had to be available to look after them whenever they were thrown off their balance by illness at work or by accident. Gradually, they would come at other times to talk to the doctor about their personal problems. The doctor in industry who fostered that approach could do a very great deal both for the individual and in identifying sources of friction in the working conditions in his factory.

A doctor at the Conference had said that one of the problems that he had had to deal with (and he had not said, incidentally, how he did deal with it) was the apprentice in a foundry who telephoned the works surgery and said " I must speak to the doctor. I have just hit the foreman on the head!" (*Laughter.*)

Mr. J. C. Z. Martin (*Chairman, Papers Committee*), moving a vote of thanks to the speaker, said that Professor Lane had presented a most competent and interesting Paper — in fact, a survey of the history, present state, and possible future trends of health services in industry. The subject was a very important one to everyone in industry, and he was quite sure that Professor Lane's Paper and his comments during the discussion, would stimulate much thought and further interest.

On behalf of the guests and members of the Institution he expressed their sincere thanks to Professor Lane for the work put into preparing the Paper, and for presenting it, and for the very full manner in which he had dealt with the questions.

The vote of thanks was carried by acclamation.

The **Chairman** said that there was a very pleasant custom within the Institution of presenting the authors of the Named Papers with a little memento of the occasion. On the present occasion, they were presenting to Professor Lane a piece of George III (1788) silver, a muffineer, in which they knew he was specially interested. He hoped Professor Lane would accept it as a memento of that evening.

The proceedings then terminated.

" Modern Trends in the Manipulation of Metals "

Publication of the Papers presented at the Institution's National Conference at Brighton in October last, will commence in the February issue of " The Production Engineer ".

COMPUTERS AND PRODUCTION

An Interim Report

by D. E. GREENE, A.M.I.Prod.E., A.M.B.I.M.
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London.

This Paper was presented during the first Session of the Symposium on "Machine Tool Control Systems", organised by The Institution of Production Engineers and held at The College of Aeronautics, Cranfield, August, 1960.

The second Paper presented during the Session, "The Production and Performance of Metrological Diffraction Gratings" appears on pages 38-44, and a report of the joint discussion on these two Papers on pages 44-49.

FIVE years ago the Institution organised a Conference to consider the automatic factory. The theme of the Conference was a big one and the Papers ranged over many fields. Statistically, there was no preponderance of any one subject. Nevertheless, there was, I think, one subject present in the minds of most of those who attended the Conference. This was the automatic transfer machine, which was at that time making a great impact on motor car manufacturers. I am sure that many of you who are here today also attended the Margate Conference and will be able to remember this. At that time there were a number of people who were saying that "automation is only another name for mechanisation". And even after the Conference they were still saying it. Except for a Paper by Mr. D. T. N. Williamson, of Ferranti, the Conference as a whole took only a side glance at computers and electronics.

Today, half a decade later, how stands automation? The development and use of transfer machines has proceeded steadily. They are now being used not only to manufacture motor car parts but also to make such things as spectacle hinges and transistors. This was expected and the phrase "automation is only another name for mechanisation" persisted for some time. But, unnoticed, and uncared for by this school of thought, another more thrilling and more momentous development has been taking place; one which really presages automation — the use of computers in production. I mean, of course, the electronic digital computer.

In this and other countries computers, both digital and analogue, have been put to such a diversity of

uses — mathematical, commercial and industrial — that it is no longer possible for one man to know all about computers and their uses. In the United States, for instance, computers are now being used for purposes as different as:

(a) controlling flood waters;
(b) compiling a short list of personnel from which to make postings;
(c) controlling a production line making carbon resistors.

It seemed to me, therefore, that before the subject becomes too complex for a simple review it would be useful to attempt to survey just one small part of the field — production — and to suggest a body of knowledge which could form a basis for still further development.

Before discussing specific cases I want to spend just a little time discussing two subjects:

(a) production technology; and
(b) the nature of digital computers.

I hope that this preliminary discussion will illuminate the cases that follow and will also stimulate subsequent discussion by the meeting.

production technology

At Northampton College, London, we have stopped talking about production engineering. Instead we talk about production technology. With all due respect to production engineers, one who wishes to control and manage a large factory must be acquainted with more than the particular manufacturing processes involved, be they woodworking, metalworking, textiles, chemicals, plastics or what you will. He needs to be able to integrate these processes with the most up-to-date knowledge and practice of materials handling, factory layout, factory building, Work Study, Operational Research, production planning, clerical and costing routines and control instruments. In this country we have an Institute of Automation, as they have in one or two European countries. But the changing and expanding examination syllabuses of this and other Institutions does show an awareness of this need. How is this integration to be achieved or partly achieved? For some little time now the problem has been urgent.

The mass urge for better standards of living has created a continually rising demand for consumer goods, and this has forced our industrial and financial giants to build bigger and more complex manufacturing units. In these huge complexes, if manufacture is not to become submerged by a morass of confused and useless paper work some device must be used which will bring order to complexity, and bring it quickly and accurately. Before passing on to consider the nature of this device, let me sum up by saying that the production technologist is one who, though deeply versed in only one or two such disciplines as physics or metalworking, is yet able to, and has to, co-ordinate the disciplines of mathematics and electronics to serve his purpose, which is the most effective and economic production of goods and services.

the nature of digital computers

The transfer machine, be it in-line, rotary or drum, has only a very limited role to play in automatic production. It merely transfers components from one machining or inspection station to another. It is true that this is a very useful role to play, in that it is done mechanically, thus saving time and labour. But it does very little else. One of the greatest requirements in all sections of a modern manufacturing unit is the need to sort out quickly a large number of variables, to make decisions and to take action — physical action — and to do all this rapidly. The essence of sorting out and decision making is rapidity and accuracy.

Let us now consider the electronic digital computer as we know it today, and as we hope it will be tomorrow. Most people still think of a computer as a very sophisticated calculating machine, and have taken notice of the debunkers who assure us that, contrary to certain kinds of popular literature, a computer is only a moron. It is not a brain. It cannot think for itself. This view may be true, in spite of another school of thought who have begun, very seriously, to experiment with what they call " thinking machines ". While there is no doubt whatever that a computer is a calculating machine, and some doubt about whether it is a " thinking machine ", the important point is that a computer is also a device for manipulating sources of energy. Viewed in this light many interesting possibilities can be visualised. A pulse of electricity, for instance, is a source of energy; it can be magnified and used to actuate a mechanism. Or it can be used as a signal to trigger off a larger, different source of energy which can be used to actuate a mechanism.

A computer, then, is both a calculating machine and a user and controller of power, and it is when both these qualities are fully utilised in the same machine that we begin to get automation. The computer today has emerged from the laboratory and the counting house and has come right out into the factory and on to the shop floor.

I pointed out, earlier, the need for integration. I do not mean integrated data processing. I mean the integration of the data processing with the physical controls of manufacturing equipment. We have not yet quite reached this stage, but we are about to reach it. I want to hurry on the journey. We shall now consider some of the ways in which computers have been applied to production problems and try to answer the question — at what stage on the journey are we?

application of computers to production

In one or more parts of the world today computers are being used for the following purposes:

machine tool control
production planning and control
line balancing
process control of continuous flow processes
optimal planning
operational research in production

control of rolling mills

sequence control of the manufacture of discrete products

machine tool control

At this meeting I propose to say very little about machine tool control. I am sure that most of you have already given considerable attention to computer controlled machine tools and are familiar with the systems involved. I do, however, want to sound a warning note. I feel that a lot of people while admitting that computer control of machine tools is a practical proposition, i.e., it works, have made up their minds that it is seldom an economic proposition. The prevailing opinion seems to be that for certain sections of the aircraft industry there are difficult contours which can be economically and quickly machined by a computer-controlled tool, but for general engineering it is not economic because of the cost of an electronically-controlled machine; that conventional machines can do the job just as well and much cheaper. This may well be so, at the moment. I do not think, however, that the last word has been said and production technologists should, I feel, preserve an open mind on the subject. Some enterprising manufacturer may yet show that he can produce a suitably designed machine tool at a competitive price. I know of at least one case where £7,000 has been paid for a copying lathe. Why boggle at present-day prices for computer-controlled tools ?

We also have, in spite of dire warnings of coming disaster, a large and thriving shipbuilding industry. Computer-controlled gas cutting machines are now in use for profiling steel plates. The system is very similar to that used for machine tools. Instead of a cutting tool such as a milling cutter the cutting heads carry oxy-acetylene gas burners (see Fig. 1). The possibilities of computer-controlled machine tools are far from having been exploited. Both in Britain and the United States much attention has been given to the milling machine, but not enough to other kinds of tools. Fig. 2 shows a contouring machine for turning, boring and grinding developed by the Ex-Cell-O Corporation of Detroit, and Fig. 3 shows some of the components produced by it.

production planning and control

Another application, of which there are several examples, but which is not being adopted rapidly enough and widely enough is production planning and control. Production control by computer is now being applied in industries as diverse as glass manufacture, ball and roller bearings, electric motors, vehicle chassis, cattle food, electrical components, photographic film, foundries, earth moving equipment, special metals, steel making, boot and shoe making, textiles and chemicals. The use of computers for production control in industries as diverse as these occurs for two **reasons :**

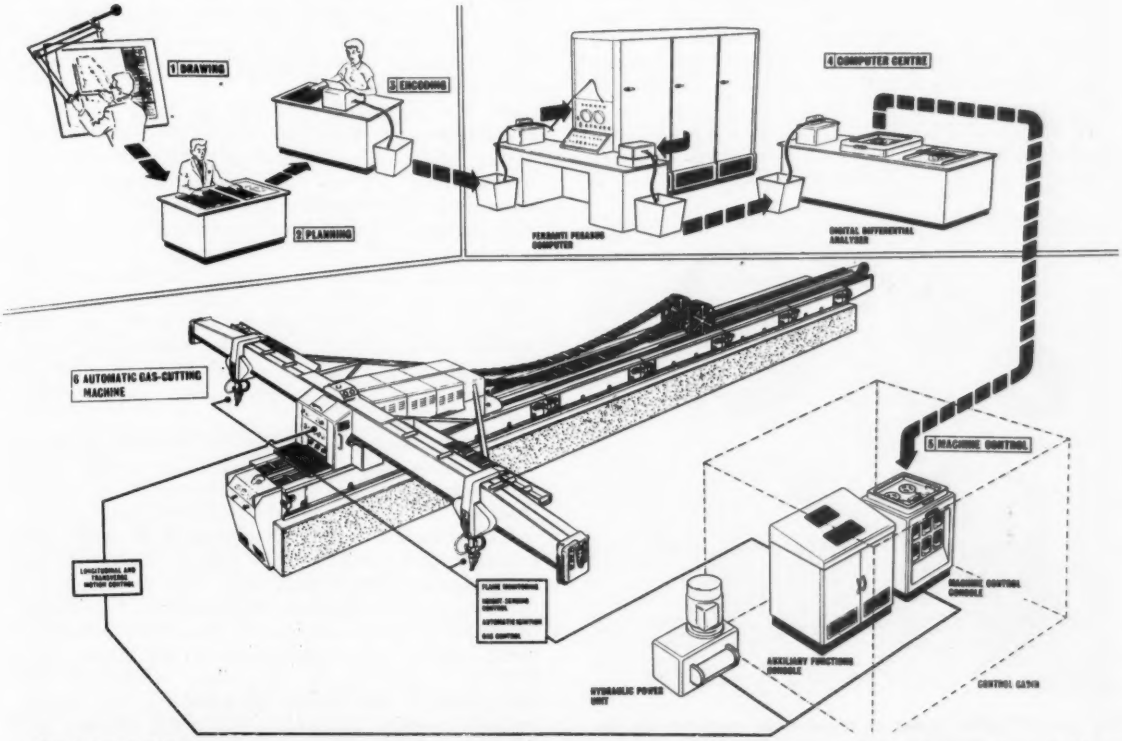

Fig. 1. British Oxygen-Ferranti computer-controlled gas cutting machine. (Courtesy of British Oxygen Gases Ltd.)

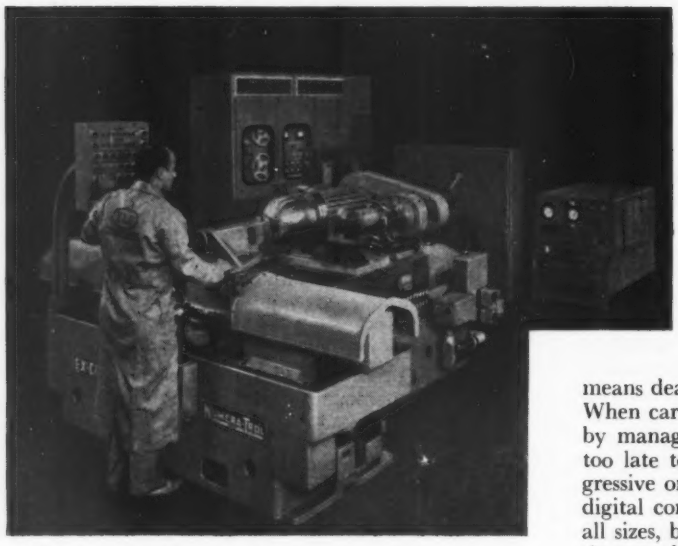

Fig. 2. Ex-Cell-O Style 922 Numera-Trol contouring machine.

(i) the very large savings in materials and the increased utilisation of machines and men that are thereby made possible;
(ii) the similarity of the problems involved.

Broadly speaking the problems of production control in all these industries are the same. These are the continuous planning of production activity in terms of the work to be done, the batch sizes or quantities to be manufactured, the loading of plant and labour, the amendment to the plan in the light of actual events, the control of material stocks and the furnishing of information to both management and the cost department.

Continuous planning has always been a distinguishing feature of production control. In the ever-growing size and complexity of modern manufacturing units it means dealing with a very large number of variables. When carried out manually the information required by management, even when it is correct, is usually too late to be of any great value. That is why progressive organisations of all sizes are turning towards digital computers to do their production control. Of all sizes, because an organisation of small or medium size can hire time at a computer centre if the purchase of a machine is not warranted.

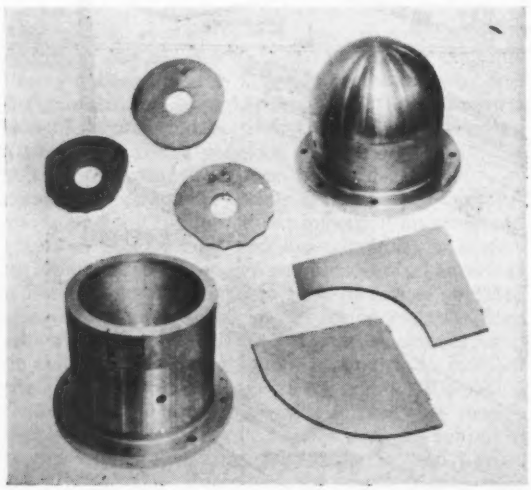

Fig. 3. A typical group of components machined on the Ex-Cell-O Numera-Trol contouring machine.

Since the problems of production control for organisations of different size and character are broadly the same, I propose to give now an outline of a computer based system which suitably adapted in part or whole is being used in many parts of industry today. The system is best illustrated by means of a Flow Chart (see Fig. 4). I am sure that most of you will agree that such a procedure is a practical proposition and is, in fact, what all production control systems attempt to do, whether computer based or not.

At the beginning of every planning period an estimate must be made (firm orders plus expectations), of the total numbers of end products required to be manufactured during that period. This is broken down into sub-assemblies and individual piece parts. Raw materials required and processing times must be calculated. Orders must be placed for raw materials, parts bought out and parts made out. Machines and labour in the plant must be loaded and shop documents produced. The calculations must take into account existing stocks, orders for spare parts, shortages and existing state of plant. Adequate and fast feedback from shops to production control centre must take place.

Any significant time lag in the feedback of information from shops to the production control centre can seriously nullify the advantages to be gained from the use of a computer. It is not enough, therefore, to install a computer to process the data. The collection and transmission of data to the centre and its receipt and preparation there must be matched to the data processing system. This can now be achieved by installing electro-mechanical data collection equipment, located at strategic points on the factory floor itself and operated by shop floor workers. This equipment is now being marketed by the leading business machine manufacturers in this country and the United States.

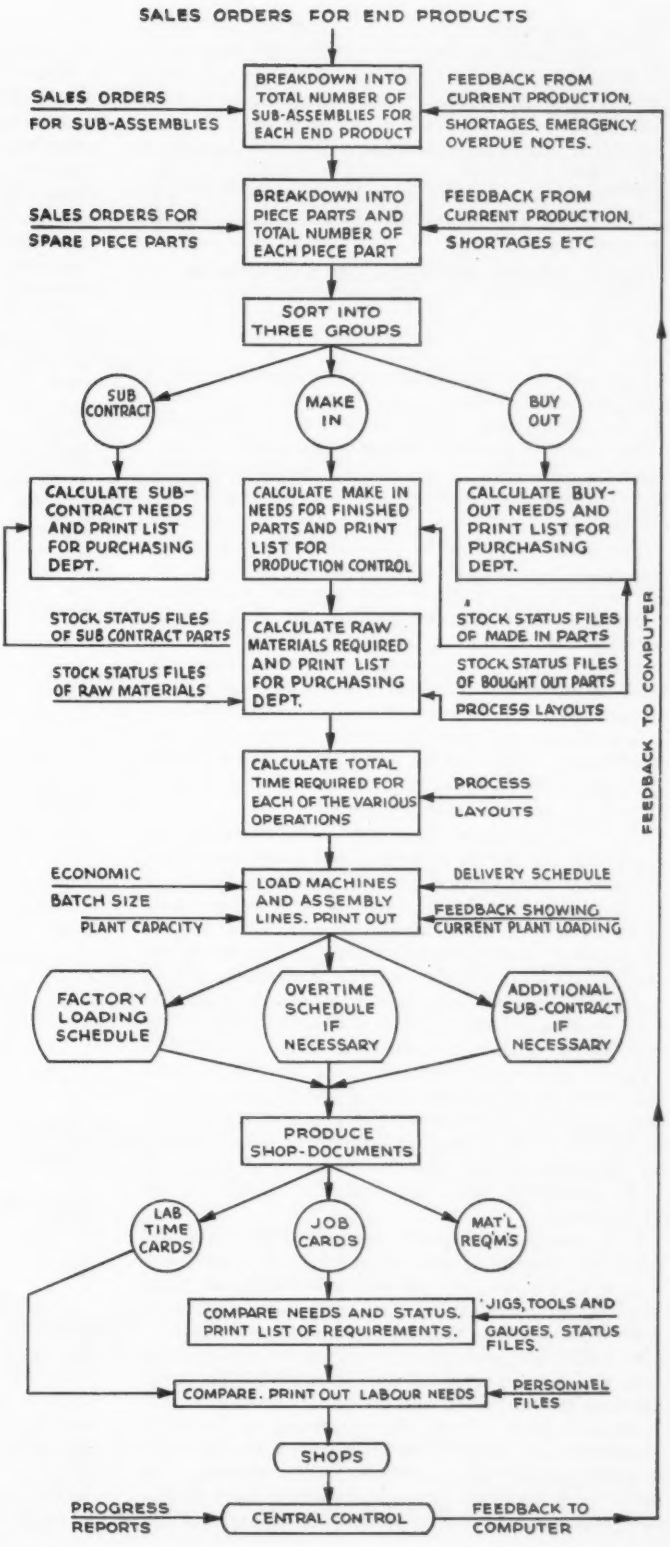
SALES ORDERS FOR END PRODUCTS
SALES ORDERS FOR SUB-ASSEMBLIES
BREAKDOWN INTO TOTAL NUMBER OF SUB-ASSEMBLIES FOR EACH END PRODUCT
FEEDBACK FROM CURRENT PRODUCTION. SHORTAGES, EMERGENCY, OVERDUE NOTES.
SALES ORDERS FOR SPARE PIECE PARTS
BREAKDOWN INTO PIECE PARTS AND TOTAL NUMBER OF EACH PIECE PART
FEEDBACK FROM CURRENT PRODUCTION. SHORTAGES ETC
SORT INTO THREE GROUPS
SUB CONTRACT
MAKE IN
BUY OUT
CALCULATE SUB-CONTRACT NEEDS AND PRINT LIST FOR PURCHASING DEPT.
CALCULATE MAKE IN NEEDS FOR FINISHED PARTS AND PRINT LIST FOR PRODUCTION CONTROL
CALCULATE BUY-OUT NEEDS AND PRINT LIST FOR PURCHASING DEPT.
STOCK STATUS FILES OF SUB CONTRACT PARTS
STOCK STATUS FILES OF RAW MATERIALS
CALCULATE RAW MATERIALS REQUIRED AND PRINT LIST FOR PURCHASING DEPT.
STOCK STATUS FILES OF MADE IN PARTS
STOCK STATUS FILES OF BOUGHT OUT PARTS
PROCESS LAYOUTS
FEEDBACK TO COMPUTER
CALCULATE TOTAL TIME REQUIRED FOR EACH OF THE VARIOUS OPERATIONS
PROCESS LAYOUTS
ECONOMIC BATCH SIZE
PLANT CAPACITY
LOAD MACHINES AND ASSEMBLY LINES. PRINT OUT
DELIVERY SCHEDULE
FEEDBACK SHOWING CURRENT PLANT LOADING
FACTORY LOADING SCHEDULE
OVERTIME SCHEDULE IF NECESSARY
ADDITIONAL SUB-CONTRACT IF NECESSARY
PRODUCE SHOP-DOCUMENTS
LAB TIME CARDS
JOB CARDS
MAT'L REQ'M'S
COMPARE NEEDS AND STATUS. PRINT LIST OF REQUIREMENTS.
JIGS, TOOLS AND GAUGES, STATUS FILES.
COMPARE. PRINT OUT LABOUR NEEDS
PERSONNEL FILES
SHOPS
PROGRESS REPORTS
CENTRAL CONTROL
FEEDBACK TO COMPUTER

Fig. 4. Flow chart for production control

In the operation of a computer-based production control system a major difficulty lies not so much in the use of a computer as in getting such a system specified, designed, started and debugged. Present-day computers are not thinking machines and cannot act, in emergencies, as shop supervisory staff would. In planning such a system, therefore, management has first to institute a systems analysis. The existing system must be studied and adapted to suit the computer. All facts must be ascertained, checked and correctly recorded on the chosen medium, be it punched card, punched tape, magnetic tape or magnetic film. This means that all drawings, all process layouts, all standard times must be ascertained and checked for correctness. All exceptions must be brought to light and incorporated in the new system or otherwise dealt with. This is no mean task when undertaken for thousands of items and usually takes several man-years to carry out. A method of smoothly and quickly incorporating changes and modifications into the system must be devised. The computer must be purchased and installed. Staff to operate and maintain the computer must be engaged. Other staff must be re-trained and briefed to accept and work the new production control system.

Managements are proceeding very cautiously because of the immense amount of expensive preparatory work to be done. The advantages to be gained, however, are substantial. In addition to large reductions of stock and work in progress and an increased utilisation of plant and labour, up-to-date information is made available to management and close and efficient control is secured.

line balancing

Line balancing is the systematic analysis of the operations (and the time required to perform them) of a group of interdependent men and machines

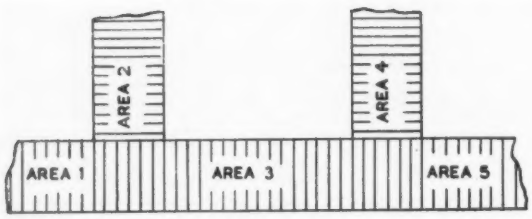

Fig. 5. Assembly line divided into area, or zones.

for the purpose of obtaining an optimum sequence of work, e.g., the assembly of an electric fire by a group of, say, 20 operators. The work is of a progressive nature and we are all familiar with many types of finishing, fabricating and conveyor assembly common to the motor car, electrical and consumer goods industries.

The usual procedure by manual methods is first to determine the number of units to be produced per day and this when related to the number of operators assigned to the work and the number of hours per working day provide a "cycle time", i.e., the time required by the line to produce one unit. The total work to be done in order to produce one unit is broken down into elements, the time for each element is determined, and each operator is assigned a group of elements, such that he can perform them within the cycle time. The work must, of course, be performed in a practicable sequence.

Given 15 or more operators each carrying out a varying number of elements, and given that there are several such groups for each product, the Work Study man doing the line balancing is being asked to find out which of several hundreds or several thousands of potential combinations of elements is the best. It is evident that by manual methods he simply cannot find the optimum combination. All he can do is to consume a large amount of time in order to find the first acceptable combination. This will contain a significant proportion of idle time for many operators, while some operators are asked to give a better than standard performance. The problem, then, when faced with a line balancing assignment is to establish the optimum combination of elements of work for each operator, and to do this quickly and economically.

Even using a computer the procedures involved would be extremely time consuming. The assembly line may, however, be divided into zones, or areas (see Fig. 5). Some elements of work can be done in more than one area and are referred to as "can-do" jobs. Other elements must be done in a particular zone and are referred to as "must-do" jobs. All elements are numbered and coded as "must-do" and "can-do" jobs. It is also necessary to establish precedence, i.e., where a certain element of work must be performed before a particular other element. Together with the times for each element of work all this information is recorded on punched cards and fed into the computer after the programme of instructions by which the assignment process will be carried out.

The computer will determine the most economical combination of elements for each operator by examining the must-do jobs, assigning them to operators and then filling up the cycle time for each operator with the best possible can-do jobs. After doing this for all operators in one zone and punching out the operator cards it will turn to the next zone and repeat the process, and so on until all zones have been dealt with and the line is balanced. Fig. 6 shows the Flow Chart for this procedure.

The use of a computer for line balancing ensures that production planning is expedited, the schedule obtained is the most economical one and this in turn leads to better and more accurate forecasting of deliveries. A further advantage is that any improvements in methods, tools, equipment and so on can be very quickly implemented because of the ease and speed with which the line is rebalanced. It may be objected that if a computer is to be used in this way the time standards supplied to the computer will need to be very accurate. Why should not time standards be accurate ?

process control of continuous flow processes

Great factories exist for producing gas and electricity, for creating nuclear products, for cracking liquids and gases, for refining oils, for polymerisation, for making steel and aluminium, textiles, chemicals, artificial fibres, plastics, paper, cattle food, cement, ice cream and fertilisers. This list is just a sample of the enormous range of products which industrial communities enjoy. It is a commonplace to say that these factories are many times more complex than their predecessors. Lunt [21] gives the following Table to illustrate the number of recorders, indicators and controllers used in a £12 million chemical plant.

	Indicator points	*Recorded points*	*Controlled points*
Temperature ...	800	250	175
Pressure ...	650	75	125
Level	250	2	75
Flow	200	100	100

Table I. Recorders, indicators and controllers in a £12 million chemical plant.

A modern electricity generating station may have anything between 600 and 2,000 points which must be monitored and controlled. Not only are vast quantities of raw materials being processed but the quality of output has to be maintained within ever narower limits of specification. This situation poses problems of control and co-ordination which can no longer be met by manual methods and conventional instrumentation. If mistakes occur because of lack of control the results may be costly and dangerous.

If quality specifications cannot be adhered to, or deviations quickly located and corrected, considerable amounts of waste and scrap may be created. A saving of only 2% or 3% in the raw materials being processed, and the energy expended for this purpose, should more than pay for a computer for a plant processing several million pounds sterling of material yearly. A greatly improved utilisation of equipment is obtained by the optimising of plant operations as the load changes from start up through on-stream, and on-stream variations, to shut down. Another advantage, because of quicker and more accurate control, will be the possibility of running plant closer to the point of failure of the materials of construction.

For all these reasons, then, a subtle and reliable means of co-ordination and control is required and, as in most process plants conditions are changeable, variables many and relationships complex, a digital computer reacts more quickly, safely and accurately than control by human beings — because of its capacity, precision and flexibility.

In considering the use of computers for process control a distinction must be made between "off-line" control and "on-line" control. In the off-line case the

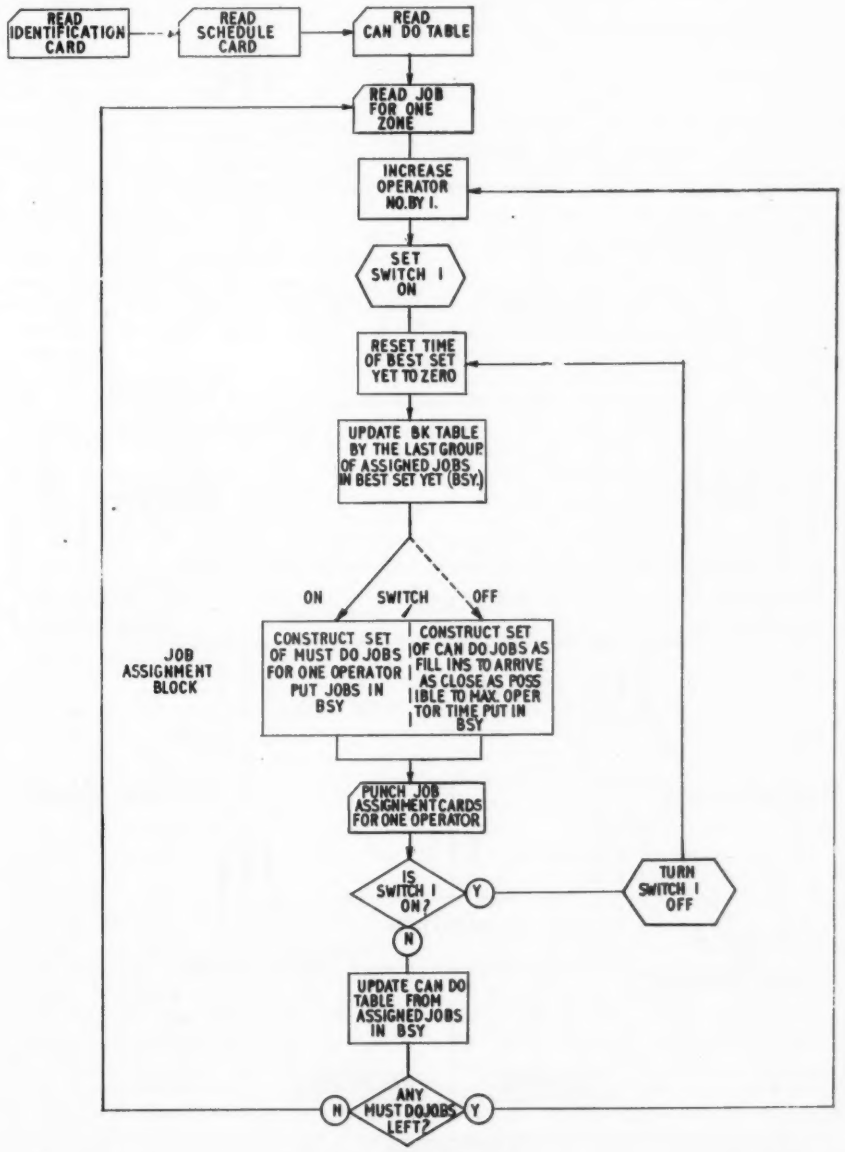
READ IDENTIFICATION CARD
READ SCHEDULE CARD
READ CAN DO TABLE
READ JOB FOR ONE ZONE
INCREASE OPERATOR NO. BY I.
SET SWITCH I ON
RESET TIME OF BEST SET YET TO ZERO
UPDATE BK TABLE BY THE LAST GROUP OF ASSIGNED JOBS IN BEST SET YET (BSY)
ON
SWITCH
OFF
JOB ASSIGNMENT BLOCK
CONSTRUCT SET OF MUST DO JOBS FOR ONE OPERATOR PUT JOBS IN BSY
CONSTRUCT SET OF CAN DO JOBS AS FILL INS TO ARRIVE AS CLOSE AS POSSIBLE TO MAX. OPERATOR TIME PUT IN BSY
PUNCH JOB ASSIGNMENT CARDS FOR ONE OPERATOR
IS SWITCH I ON?
Y
TURN SWITCH I OFF
N
UPDATE CAN DO TABLE FROM ASSIGNED JOBS IN BSY
ANY MUST DO JOBS LEFT?
N
Y

Fig. 6. General block diagram for line balancing. (Courtesy of IBM)

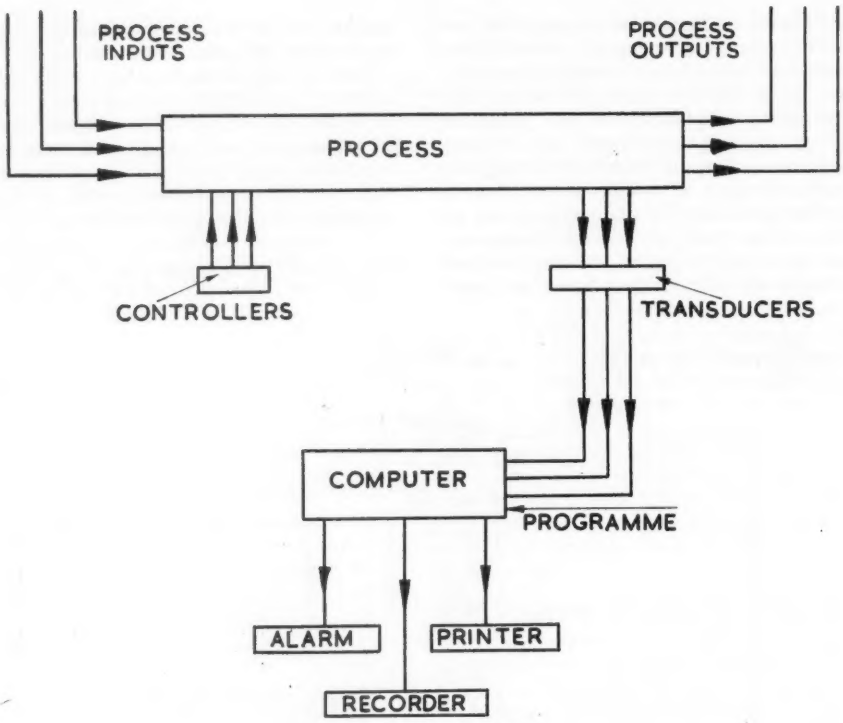

Fig. 7. Computer off-line.

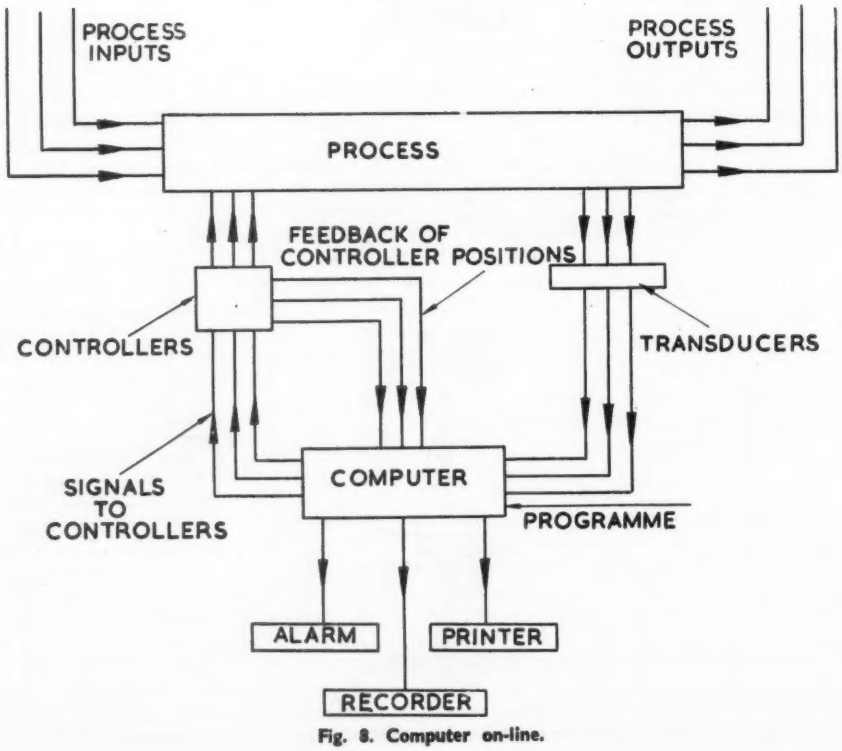

Fig. 8. Computer on-line.

control loop is not directly closed. In on-line control the loop may be closed. Figs. 7 and 8 make this clear. In off-line control the measurements from the process are converted, where necessary, to digital form and fed into the computer. The computer takes this information, compares it to certain predetermined parameters, makes some calculations and then, after recording the information, prints out the results of the calculations and sends out signals. The operator, or operators, observing the output from the computer, must then decide what adjustments to make to the plant operation and must proceed to make them manually — by pressing buttons, operating switches, manipulating valves and so on.

Clearly, several possibilities are present. Operators may observe incorrectly, may take time to assimilate their observations and relate them to the predetermined set points; will certainly require time to make the adjustments manually and may even make these adjustments incorrectly or insufficiently. The reduction of these hazards of manual operation is achieved by closing the loop. We have noted that a computer can be used not only for data processing but also as an initiator of control signals. These signals from the computer are used to actuate the controllers without the need for manual intervention. The computer not only determines correctly what adjustments should be made but proceeds also to make these adjustments quickly and accurately.

This is not the place to go into the detail of computer design. Most of us here will already have acquired at least an elementary knowledge of the technique of computers — binary codes, transistors, cores, logic, drums, discs and so on. It is perhaps worthwhile pointing out, however, that the manufacture of computers suitable for process control in the manner just described has been made possible by the rapid development of analogue to digital and digital to analogue devices 22. The behaviour of the plant must be measured and, at the present time, these measurements — temperature, pressure, flow and the like — are usually in analogue form. They must be digitised if the computer is to deal with them. Transducers of various kinds are used to convert the measurements to voltages or shaft rotations, two common forms of input which can be conveniently digitised. Similarly the output from the computer can be translated as voltages or shaft rotations and these in turn can be used to control the electrical or pneumatic signals which actuate the process controllers.

To what extent have the computer-controlled systems just outlined been put into practice in this and other countries ? Common prudence makes users and manufacturers loath, at this stage, to give detailed and precise information. We do know, however, that both Ferranti and Elliott are offering computers for process control systems. A.E.I. Ltd. have a computer installed at Calder Hall for monitoring, processing and storing information resulting from a count of the fission product activity in samples of reactor coolant gas 26. From the United States comes a thin but steady stream of reports of process control applications, both off-line and on-line. Some of the processes concerned are power generation, oil refining, chemicals, gas distribution and cement manufacture.

I quote from *Control Engineering*, January, 1960, "Completely automatic production control of an electric apparatus fabricating plant will go on-line this year. A dozen major chemical processing units will be computer-controlled." One should note that these are forecasts or expressions of firm intentions. When 1960 ends progress can be reviewed and although this may not match aims we can feel confident that progress will have been made.

optimal planning

Optimal planning is a mathematical procedure for finding the most profitable production plan to follow in those cases where the factors of production are many and variable. Some of these factors are raw material costs and proportions to mix, labour costs, other production costs, demand, specifications and so on, together with any constraints that exist, e.g., limitation of material handling facilities, selling prices. Examples are to be found in the steel, cattle food, fertiliser, oil refining and batch production industries.

This procedure, of which linear programming is only one of the better known methods, consists of examining all possible combinations, variations and/or permutations of these factors in order to select that which gives the desired results, which may be maximum output, minimum cost, a certain chemical specification or optimum utilisation of facilities and equipment; and to complete this examination within a reasonable time — or at a certain fixed time — so that the results can be of use to management.

As the mathematical tool used to conduct the examination must be chosen to suit the needs of the case, it is not proposed to deal with this aspect of the topic but only to give an example of optimal planning which although it has been reported before 2 is not as widely known as some examples in the oil industry. The oil industry is such a vast and specialised industry that its cases are apt to be dismissed as not relevant to the rest of industry. The example now presented is that of ore-digging forecasting carried out by the Stewarts & Lloyds organisation at Corby, Northamptonshire. It is thought that this case may stimulate consideration of other such problems which at first sight do not appear amenable to treatment by a digital computer. An optimal planning problem does not invariably require the use of a computer but if a large number of combinations of many variables are to be explored rapidly, then the use of a computer is almost obligatory.

At Corby a decision must be made each day as to what amounts of iron ore are to be dug, the next day, from each of a number of pits in order that when combined, the total forms a mix of suitable chemical analysis for input to the blast furnaces. It is hoped also to make a tentative forecast of the digging programme for the following four days. This latter forecast will then be revised each day in accordance with the results of the current day's digging.

The need for this decision making arises because although the pits are located fairly close to each

other in one large area the chemical content of the iron ore over the whole area is not uniform and can vary in the form of pockets of different composition. Each day, therefore, as the baring digger removes the crust of earth from the strips of ore in one or more pits, samples are taken from the exposed sections of ore and sent to the laboratories for chemical analysis. It is from an analysis of these samples that a suitable digging programme must be obtained by calculating how many wagons of ore are to be dug from each pit in which digging operations are taking place in order to secure a total furnace input of the required analysis.

The analysis of a mix is a function of the amounts and content of the various parts that go to form that mix. As iron ore contains a number of chemical constituents each of which, in this case, can vary independently of the others in different parts of the area, it is evident that the examination of the samples and their combination in various amounts in order to obtain the optimum mix is an iterative procedure of some length and complexity. It is necessary also to take into consideration any drilling, blasting and draining operations that are required and may be going on in one or more pits; and to arrange that the starting points of the next day's operations, which are the finishing points of today's operations, shall secure an equally good mix.

Prior to the advent of the computer Leo II/3, this work of forecasting the digging programme was carried out manually, with the aid of a desk calculator. Guided by experience and using his intelligence — and perhaps some intuition — the forecaster simply made an arbitrary start by allocating a certain number of wagons to each pit in use, working out the analysis of the resulting mix and comparing it to the desired specification. The results of the comparison guided the subsequent trial and error procedure until an acceptable analysis was obtained. It is important to emphasise that, owing to limitations of time, the aim was to obtain an acceptable mix. Now it is possible to aim at the optimum mix, once a yardstick has been established.

No savings in manpower are obtained by using the computer for this purpose but the potential gains are a better use of the blast furnaces and a more economic use of the pits themselves.

Operational Research in production

If Operational Research be defined as the attempt to discover and control the relationships between men, machines and their environment in some system of complex interdependent activities then, clearly, there is ample scope for Operational Research in the field of production and its ancillary activities. Although Operational Research is still, perhaps, only in its infancy several well-defined types of problem have already emerged as suitable for solving on a computer — inventory, optimum mix, queueing, transportation, replacement and combinations of these. Nearly all have some bearing on the efficiency of production.

A case that will be of some interest to production technologists and factory managers in many industries is one concerned with the scheduling of furnace repairs in an open-hearth melting shop. The problem is a familiar one in those organisations using several or many sets of almost identical plant, e.g., boilers, pumps, distillation units, generators, foundry equipment and so on. In attempting to fit repair and maintenance gangs to the repairs required more than one set of equipment may require repairs at the same time, or all equipment is in production and the repair gangs are idle. Not only does this reduce the utilisation of men and machines; it also creates a fluctuating output from the factory as a whole and may in time create further difficulties and an uneven flow of work at subsequent stages of processing.

The need, therefore, is to evolve a system which, bringing order into the scheduling of repairs, reduces idle time of both men and equipment and enables the output from the factory to be maintained consistently within known limits. A brief outline of the open-hearth furnace repair case now follows and it is hoped that this will help in suggesting the approach to the solutions of similar problems.

Open-hearth furnaces have an average life between repairs of 10 - 15 weeks and a repair time of between 1 - 4 weeks. At the end of a "life" they require either a top repair (i.e., a new roof), or a general repair (i.e., a more thorough reconstruction). These two types of repair which alternate with each other are undertaken by one or more repair gangs. Each gang is composed of two sections, a demolition squad and a brick-laying squad.

The Model. In order to decide the best course to adopt at any one time, it was found necessary to construct a mathematical model to simulate any of three kinds of repair schemes and the effect of each on the existing state of the melting shop and the course of production. These three schemes are known as *laissez-faire*, scheduling and forecasting. Under the *laissez-faire* scheme furnaces are kept in production until such time as "fall-in" point is reached, and it would be unwise to attempt another heat. If, at this time, other furnaces are undergoing repairs then these repairs must be completed before attending to the furnace which has just reached fall-in point. This furnace, therefore, remains idle until one of the repair gangs is ready for it.

Under the scheduling scheme each furnace is repaired when it reaches a predetermined proportion of its average life, irrespective of whether or not it has reached fall-in point. If, however, the repair gang is already occupied, then the furnace is kept in production until it does reach fall-in point or the repair gang is ready for it. If it reaches its fall-in point before its scheduled life is attained then it must be dealt with as under the *laissez-faire* scheme. A common ratio of scheduled life to average life is 7/8.

In the forecasting scheme, however, because both oil and tar are used as fuel each furnace has its own average life. Values for the actual life of a furnace during the subsequent simulation were obtained by random sampling of a previously stored normal distribution of mean unity and multiplying by that

furnace's individual average. In order to obtain repair times the average time was multiplied by a random sample obtained from a stored distribution. The remaining anticipated life of each furnace was then calculated every 10 days or so by means of the following formula :

$$Et,r = r + \left(\frac{t-r}{t}\right)\left[\left(1-k_1\right)t + k_1 Et,r-1 + k_2 tUr\right]$$

where :

Et,r is the estimate made at time r for a furnace with actual life t.

k_1 and k_2 are constants which can be varied to give different shaped forecast curves.

Ur is a random normal error term.

The next step occurs when a repair gang becomes free. If no furnace has then reached fall-in point it is necessary to determine if a repair should be put in hand immediately and, if so, which furnace is to be repaired. The estimated lives and expected repair times of all furnaces are inspected. If Ei and Ri are the estimated life and expected repair times of the ith furnace then for each i the expression

$$Fi = Ei - \sum_{j=1}^{N} Rj$$

is calculated for all j such that $Ej < Ei$ where N is the number of furnaces in the shop. This determines whether or not the expected repair times of all the furnaces with a shorter estimated life than furnace i can be completed before the estimated fall-in point of furnace i is reached.

Clearly, if there is not time to carry out all the earlier repairs before furnace i reaches its fall-in point a repair must be started on the furnace with the smallest estimated remaining life. If all Fi are positive then there is no need to start a repair at once. The minimum Fi is ascertained and a repair started then, or sooner if any furnace reaches its fall-in point.

In all three schemes the demolition squad of the repair gang is able to start work on a second repair before the brick-laying squad has finished its work on an earlier repair. A second possibility is that a general repair may not have been long under way when another furnace becomes due for a top repair. In this instance it would pay to stop work on the first furnace, carry out the top repair, and then return to the general repair. The model incorporates both these possibiltiies.

The Programme. In writing a programme for this kind of simulation, either the unit scan principle or the event-to-event principle may be used. For the unit scan method a basic time interval is selected and advanced one unit at a time. On each advance the items are scanned to find what activities have been performed and to take action accordingly. If no activity has been completed a further advance of one unit is made and another scan carried out, and so on.

In the event-to-event method the advance is by variable stages, each stage taking the simulation to the next event. Since the event-to-event method was chosen for this case, as it is usually the quicker, the following events had to be taken into consideration :

(i) For each furnace :
time fall-in point reached;
time demolition gang finishes;
time brick-laying squad finishes;
time scheduled life reached (scheduling scheme only).

(ii) For the whole shop :
time at which repairs can be just fitted in (forecasting);
time at which new estimates are due;
end of period.

(iii) The remaining estimated life of each furnace (forecasting);
the master clock.

For work of any complexity, flow charts have usually to be prepared before the programme can be written. In this case it is also considered desirable to use an autocode. Although machine time was longer a considerable saving was made in programming time. The actual programme would probably be of no interest to readers who are not familiar with the autocode concerned and is therefore omitted. The flow charts, however, should be of interest as they demonstrate the logic of the simulation, and are given in Figs. 13 - 21 in the Appendix.

It was necessary, also, to prepare a parameter tape and a steering tape. The parameter tape holds a set of instructions for reading in and storing distributions of furnace lives and repair times. In addition it contains the initial states of all the furnaces and facilitates the printing of results. The steering tape selects one of the systems for simulation and changes, when required, any set of parameters, e.g., average repair times. As many periods may be simulated as deemed necessary.

I suggest that the above procedure, or adaptations of it, can be applied to many other similar problems. It is noteworthy that the simulation technique was employed.

control of steel rolling mills by digital computers

In the steel industry it is often necessary to roll ingots and slabs in order to reduce them to a given thickness. This is done in a rolling mill by making several passes in both directions, and sometimes turning a slab 90° after an intermediate thickness is reached, and then rolling to final thickness. The draft, or reduction in roll opening, is regulated between passes. This reduction is carried out by means of a screwdown mechanism.

The problem here is to decide after each pass what the next draft is to be. The factors to be considered are :

1. the composition and temperature of the metal being rolled.
2. the desired physical and metallurgical properties;
3. the intermediate thickness, if any;
4. the final thickness;

5. the final width;
6. the roll separating force;
7. the driving motor torque.

Up to now, in both Britain and the United States, the decision was made by the operator relying on his experience to guide him. Under these circumstances it is most unlikely that the optimum draft will be obtained.

In this country a British firm has now taken out a patent "based on the utilisation of a mathematical relationship which had been determined between the roll-separating force in consecutive passes and the draft in these passes. A computer can be designed or set for continuously solving the equation expressing this relationship, and the set up will then consist of a computer in combination with the mill"*.

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* From "The Engineer's Digest," Vol. XXI, No. 4, April, 1960, page 81. British Patent Specification 818,952. United Steel Companies Limited, Sheffield.

In the United States there is at least one rolling mill actually at work in combination with a computer. The hot plate mill concerned is a new slabbing mill installed in the Lukens Steel Company, of Coatesville, Pa. It is important to note that the mill concerned is not a mass production factory, but what we in the United Kingdom call a "jobbing shop", i.e., each order is only infrequently repeated, if at all.

In steel rolling, as in metal cutting, if production is continuous and repetitive the operator's task is simplified by the need to make only one setting. But in job production frequent settings have to be made. In the case of a rolling mill this means many calculations, the application of setting reference signals to the roll screwdown system and control of all the many passes necessary. At Lukens this work is now being done by a special purpose digital computer. The computer not only makes all the calculations necessary to determine the next draft, it also operates the rolls and mill table, and the screwdown mechanism to obtain the next draft position.

Fig. 9 is a block diagram of the new control system in the Lukens mill and shows both inputs and outputs. The operator feeds in the following information:

1. initial roll opening, which depends upon ingot size—knowing the size of the mould only a light draft is set for the first pass because the ingot is tapered and a main purpose is to break up any scale;
2. the intermediate thickness limit—this is only necessary when slabs are being rolled and are going to be turned through 90° at this stage;
3. the final thickness;

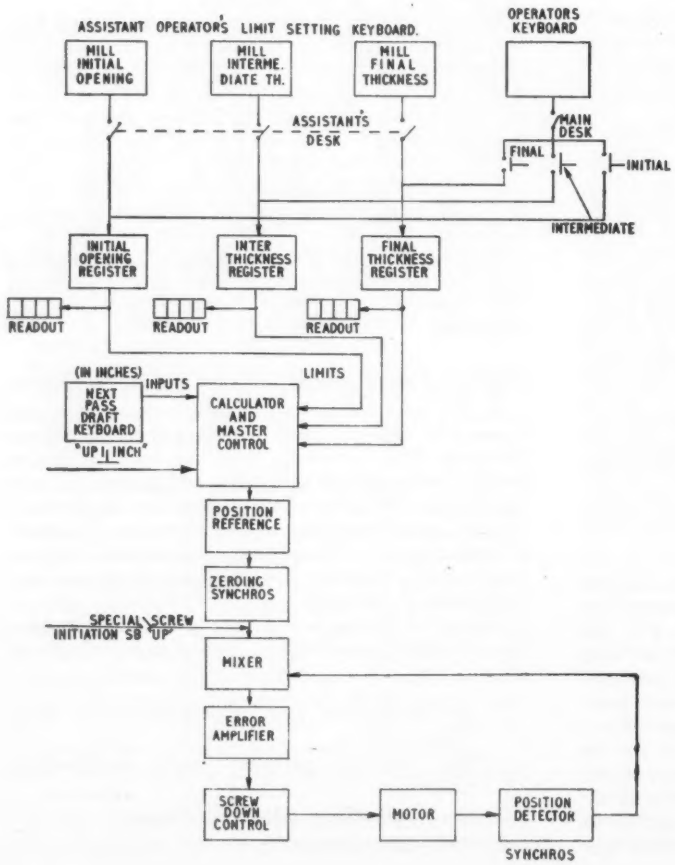

Fig. 9. Block diagram of control system for rolling mill.

4. the next draft, which is to be taken on all passes after the first pass, except when approaching the intermediate and final thicknesses — the magnitude of this draft depends, of course, on the composition of the metal and the qualities desired in the finished piece.

"Automatic operation is started when the operator presses the 'screw reset' button which causes the contents of the 'initial opening' register to be placed in the 'preset opening' register, the output of which is converted to an analogue synchro signal and becomes the reference for the roll screwdown sensory system. After this initial setting, the computer calculates the new desired screw openings for each pass by subtracting the next draft from the present opening and comparing the results with the limits"*.

Among other things the computer displays the following information for the convenience of the operator:

1. the operator's instructions, stored in registers until used in the calculations;
2. the actual draft employed in each pass;
3. the number of passes that have taken place since the start of the operation.

The computer and control equipment are, of course, of current design with transistors and modular construction.

sequence control of the manufacture of discrete products

We come now to a case which is perhaps the most interesting case of all — the production of carbon resistors at the Western Electric Company's plant at Winston-Salem in North Carolina. The more or less automatic processing of a continuous stream of material such as oil, flour, paper, cement, ice cream, has been with us for a considerable number of years and it was quite early realised that such processes might lend themselves to control by computer within foreseeable time. But when discrete components were mentioned the wiseacres shook their heads. The difficulties seemed too great.

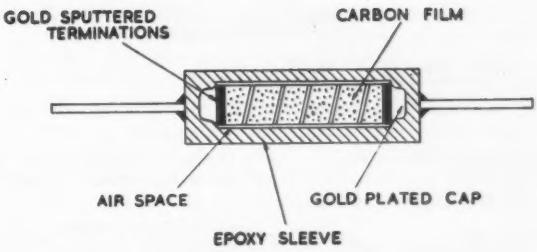

Fig. 10. Carbon resistor.
(Courtesy of "Aviation Week")

Since the end of the Second World War there have been very rapid developments in mechanical handling aids, inspection devices and in electronic and hydraulic controls. The first flowering of these developments was the transfer machine. Now we have the manufacture of the carbon resistors shown in Fig. 10. I am not able to give as much information about this case as I would like, because complete details have not yet been released. Many items are of a confidential nature.

The resistors are made in the production line shown in Fig. 11. The whole line is controlled by an LGP 30 digital computer situated at the head of the line. The computer controls the entire manufacturing process including work scheduling, machine changeovers and quality control. The sequence of operations is

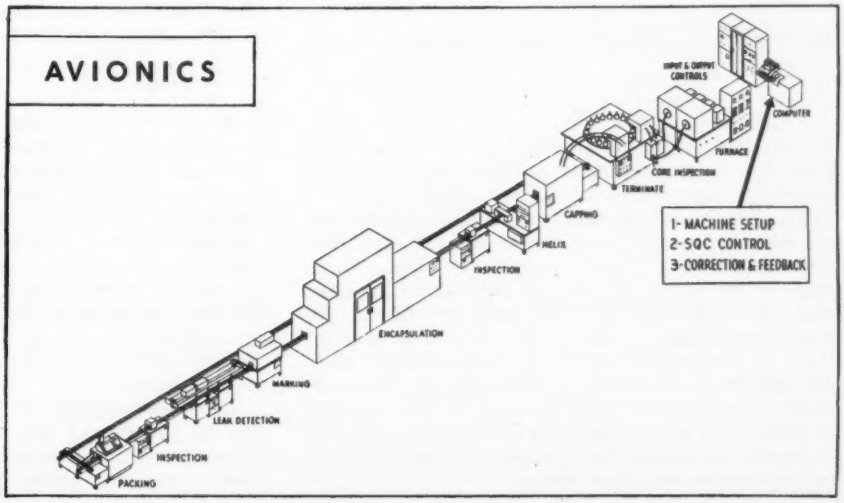

Fig. 11. Production line for carbon resistor.
(Courtesy of "Aviation Week")

* This passage and Fig. 9 are reprinted from "Control Engineering," January, 1960. Copyright © 1960 by the McGraw-Hill Publishing Co., Inc. All rights reserved; whose Editor has kindly given the Author permission also to draw on the article "Digital Computer Runs Hot Plate Mill" for some of the material contained in this section of this Paper.

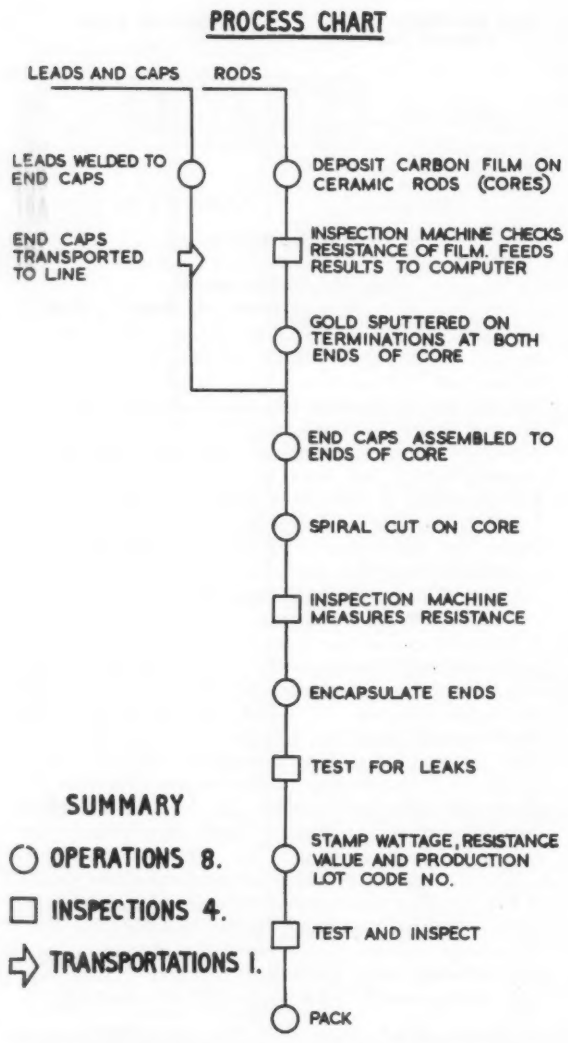
PROCESS CHART
LEADS AND CAPS
RODS
LEADS WELDED TO END CAPS
END CAPS TRANSPORTED TO LINE
DEPOSIT CARBON FILM ON CERAMIC RODS (CORES)
INSPECTION MACHINE CHECKS RESISTANCE OF FILM. FEEDS RESULTS TO COMPUTER
GOLD SPUTTERED ON TERMINATIONS AT BOTH ENDS OF CORE
END CAPS ASSEMBLED TO ENDS OF CORE
SPIRAL CUT ON CORE
INSPECTION MACHINE MEASURES RESISTANCE
ENCAPSULATE ENDS
TEST FOR LEAKS
SUMMARY
OPERATIONS 8.
INSPECTIONS 4.
TRANSPORTATIONS 1.
STAMP WATTAGE, RESISTANCE VALUE AND PRODUCTION LOT CODE NO.
TEST AND INSPECT
PACK

Fig. 12. Process chart showing production of carbon resistor.

shown by the Process Chart (Fig. 12). The usual procedure is to prepare a punched tape showing, sometimes, up to as much as one month's requirements. The computer then programmes production according to wattage and resistance. Sizes manufactured range from $\frac{1}{8}$ watt to 2 watts. The $\frac{1}{8}$ watt units are produced at a rate of 2,400 units per hour and the larger sizes at 1,200 units per hour. At nearly every stage in the process there is both feedback of inspection results to the computer and adjustment of the process or operation by the computer. The computer takes account of the number of rejects and automatically increases the number of cores sent to the carbon deposition furnace in order to compensate for these rejects.

Furnace temperature, flow of gas and rate of travel of cores must be measured and transmitted to the computer. During the spiralling operation, carried out by a diamond wheel, the resistance being achieved must be continuously measured. The same sort of devices as are used in a continuous process application are used in this application — thermocouples, flowmeters, Wheatstone bridges, photoelectric sensors, and so on.

Although a carbon resistor is a comparatively uncomplicated product there is much scope for error and faulty work. It is necessary to find a method of manufacture which would incorporate closer control of the whole process within narrow limts, to operate this control consistently and to reduce the percentage of rejects being created. This necessity had become urgent because resistors are required in tens of millions for the inter-Continental ballistic missile project and for the Bell telephone system. It is claimed that with computer control the desired resistance can be controlled to within 2% instead of the previous 25% 25.

conclusion

We have discussed a number of different cases in which a computer has been used in the field of production. What conclusion can be drawn from these examples ? Simply this — that the electronic digital computer is now as much a new and revolutionary tool of production as the steam engine was in its day. The reasons why computers are not being used in production as much as they ought to be are :

1. a lack of appreciation of their potentialities in this field;
2. rapid development of the technique has not been accompanied by similar action to educate management and practising engineers;
3. the large sums of money involved both in capital expenditure and in the preparation and installation stages;
4. many problems of application are still unsolved and progress is slowed by the current small number of installations which hinders the growth of experiment and the spread of user experience.

In view of the continuous and rapid development in both design of machines and the components, hardware and peripheral equipment generally, it is understandable that many managements think it only prudent to wait for a period of stability and accummulated wisdom before investing in such an expensive machine. It would now appear, however, that there is unlikely to be a period of such stability and progressive managements have no longer this excuse for not taking the plunge. With so much research activity going on we must accustom ourselves to continual change.

The large capital cost is to some extent mitigated by the variety and size of machines now available. There are small machines, medium-sized machines. large machines, special purpose machines, general

purpose machines, machines for data processing and machines for scientific calculations. Prices may be anything from about £20,000 to over £500,000. The time is very rapidly approaching, if it has not already arrived, when every large and medium-sized manufacturing organisation ought to have a computer, and small organisations ought to be hiring time on one. Even now there are firms which own more than one computer. These are, of course, large organisations who need a computer for the many and complex calculations carried out by their design and research departments.

To be more specific, how can a computer be justified ? The manner, place and time in which this tool of production should be used is governed by the same, and also by different considerations, as govern any other item of production equipment. Economy and ease of use, reliability of operation, ease of maintenance, capital cost; all must be rigorously examined.

One of the conventional considerations is — special purpose or general purpose ? In process control and sequence control of manufacturing operations where it may be possible to place the computer in the factory itself a special purpose computer seems to be the obvious choice, e.g., in the manufacture of carbon resistors, the control of steel rolling mills, the control of a polymerisation unit. For such an application, however, the choice of a special purpose computer is not axiomatic. A computer can work at such high speeds that in between scanning and making the necessary calculations there may be idle periods of one, two, three or even more minutes.

It would be wasteful not to use the computer during these periods and this has led to the concept of time sharing, i.e., sharing the computer's time between several different programmes or jobs. With a computer being employed for an on-line application it might not be easy to arrange for time sharing. Data processing centres, however, can arrange for both time sharing and a succession of different jobs. In this latter case a general purpose machine is called for. Here there is a further subdivision — general purpose for commercial and industrial data processing or general purpose for scientific, research and design calculations. Since we are discussing production technology it appears that a general purpose machine for data processing is required. i.e., a large, fast machine with adequate storage capacity capable of being expanded on the modular principle. Production control, stores control, payroll and accounting procedures can be carried out regularly on such a machine.

These procedures, however, do not exist for their own sake. They exist to serve and should be geared to the production line itself. There are also possibilities of so integrating them with each other as to reduce the total amount of work to be done. Up to now these procedures have existed separately from the production processes. The increase in size of factories has confronted managements with the urgent need to control vast quantities of labour, materials and equipment. To attempt to do so with an army of clerks, first-line supervisors and outmoded administrative procedures is sheer folly.

It will not be easy to draw up the usual before and after cost comparison statement, so establishing a cast iron economic argument for a computer, because in a large number of applications the cost of doing the job by the previous method was not known and was, in fact, not easily ascertainable. This is no excuse for not looking carefully into the economic aspect of any proposal. We have seen also that the use of a computer does not simply mean replacing an existing machine and/or a number of clerks by the more sophisticated computer.

It usually means cutting across the conventional lines of division of administration and the construction of new systems. This makes it difficult to assess the cost of doing a job by a computer, comparing it to the cost of the old method and, solely on the results of the comparison, accepting or rejecting the proposal. The majority of those managements who have applied computers to production have expressed their satisfaction with the results, among which ease and speed of control were very important.

The main justification for a computer then, is not only the substitution of one machine by a better one but the urgent need to revolutionise our concept of production and production control in order to progress with that speed and economy vital to maintain the position of Britain in the world of today and tomorrow.

acknowledgments

I would like to thank the many people — both users and manufacturers of computers — who have made this Paper possible by supplying me with information and case studies and allowing me to visit their factories and talk to their executives. Acknowledgments are due particularly to the management of Stewarts & Lloyds, Corby, Northamptonshire, for the case study on Optimal Planning; and to the Editors of *Control Engineering* and *Aviation Week* for the case studies of the hot plate mill and the carbon resistors. Some of the material on which this Paper is based will appear in a more lengthy form in a forthcoming book to be published by Chapman & Hall Ltd., London.

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APPENDIX (Figs. 13 - 21)

FLOW CHARTS FOR CASE STUDY OF OPERATIONAL RESEARCH IN PRODUCTION

see pages 35 - 37

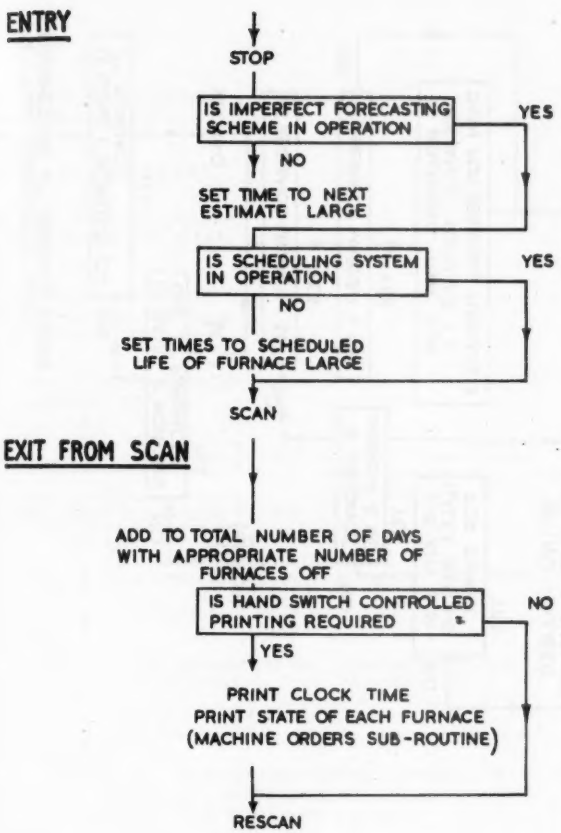


Fig. 13.

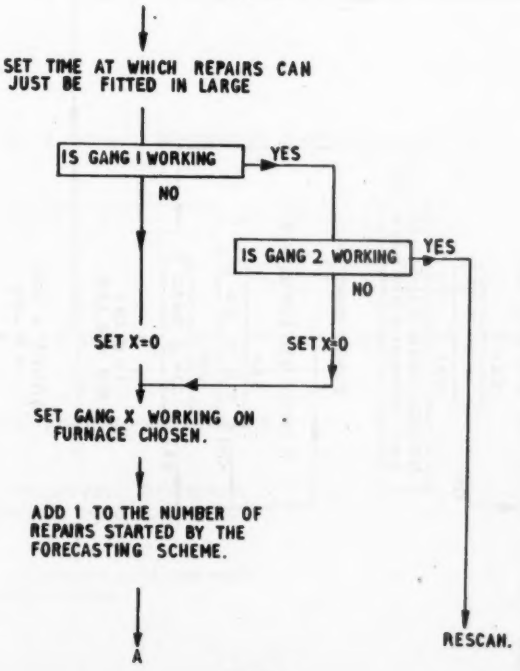


Fig. 19.

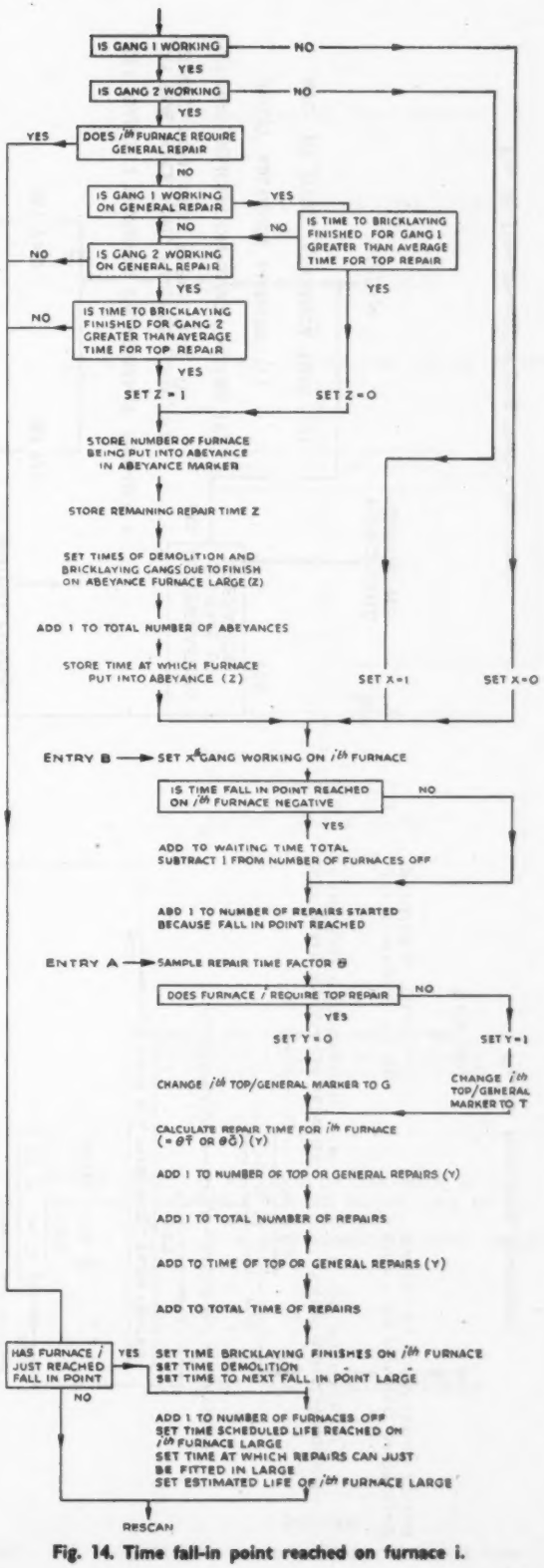

IS GANG 1 WORKING
NO
YES
IS GANG 2 WORKING
NO
YES
YES
DOES i^{th} FURNACE REQUIRE GENERAL REPAIR
NO
IS GANG 1 WORKING ON GENERAL REPAIR
YES
NO
NO
IS TIME TO BRICKLAYING FINISHED FOR GANG 1 GREATER THAN AVERAGE TIME FOR TOP REPAIR
NO
IS GANG 2 WORKING ON GENERAL REPAIR
YES
YES
NO
IS TIME TO BRICKLAYING FINISHED FOR GANG 2 GREATER THAN AVERAGE TIME FOR TOP REPAIR
YES
SET Z = 1
SET Z = 0
STORE NUMBER OF FURNACE BEING PUT INTO ABEYANCE IN ABEYANCE MARKER
STORE REMAINING REPAIR TIME Z
SET TIMES OF DEMOLITION AND BRICKLAYING GANGS DUE TO FINISH ON ABEYANCE FURNACE LARGE (Z)
ADD 1 TO TOTAL NUMBER OF ABEYANCES
STORE TIME AT WHICH FURNACE PUT INTO ABEYANCE (Z)
SET X=1
SET X=0
ENTRY B
SET X^{th} GANG WORKING ON i^{th} FURNACE
IS TIME FALL IN POINT REACHED ON i^{th} FURNACE NEGATIVE
NO
YES
ADD TO WAITING TIME TOTAL
SUBTRACT 1 FROM NUMBER OF FURNACES OFF
ADD 1 TO NUMBER OF REPAIRS STARTED BECAUSE FALL IN POINT REACHED
ENTRY A
SAMPLE REPAIR TIME FACTOR θ
DOES FURNACE i REQUIRE TOP REPAIR
NO
YES
SET Y = 0
SET Y = 1
CHANGE i^{th} TOP/GENERAL MARKER TO G
CHANGE i^{th} TOP/GENERAL MARKER TO T
CALCULATE REPAIR TIME FOR i^{th} FURNACE ($= \theta\bar{T}$ OR $\theta\bar{G}$) (Y)
ADD 1 TO NUMBER OF TOP OR GENERAL REPAIRS (Y)
ADD 1 TO TOTAL NUMBER OF REPAIRS
ADD TO TIME OF TOP OR GENERAL REPAIRS (Y)
ADD TO TOTAL TIME OF REPAIRS
HAS FURNACE i JUST REACHED FALL IN POINT
YES
SET TIME BRICKLAYING FINISHES ON i^{th} FURNACE
SET TIME DEMOLITION
SET TIME TO NEXT FALL IN POINT LARGE
NO
ADD 1 TO NUMBER OF FURNACES OFF
SET TIME SCHEDULED LIFE REACHED ON i^{th} FURNACE LARGE
SET TIME AT WHICH REPAIRS CAN JUST BE FITTED IN LARGE
SET ESTIMATED LIFE OF i^{th} FURNACE LARGE
RESCAN

Fig. 14. Time fall-in point reached on furnace i.

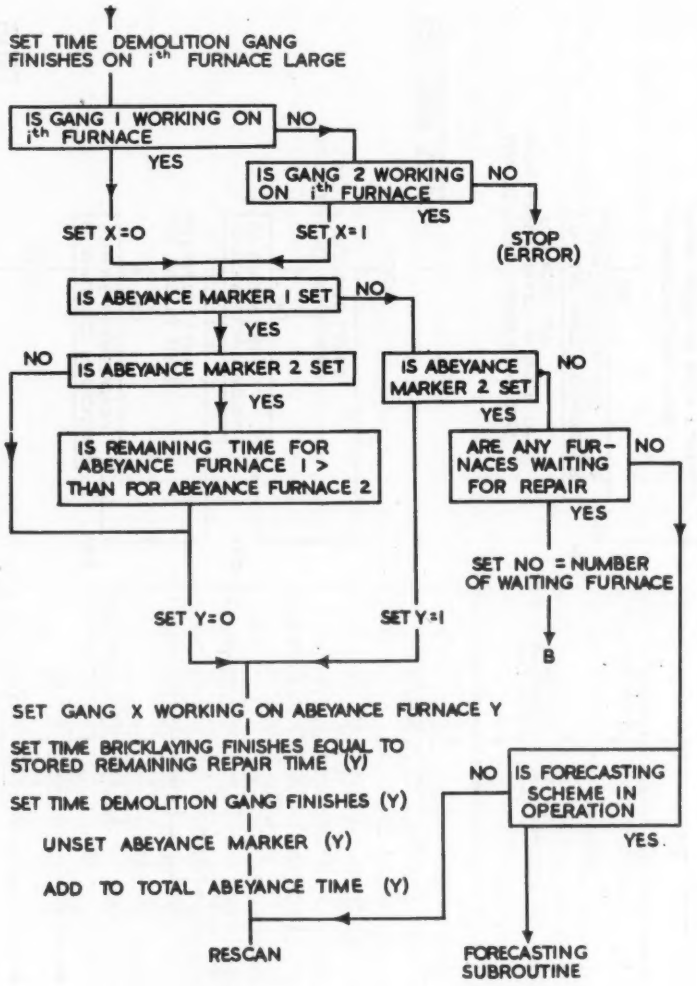


Fig. 15. Time demolition gang finishes on furnace i.

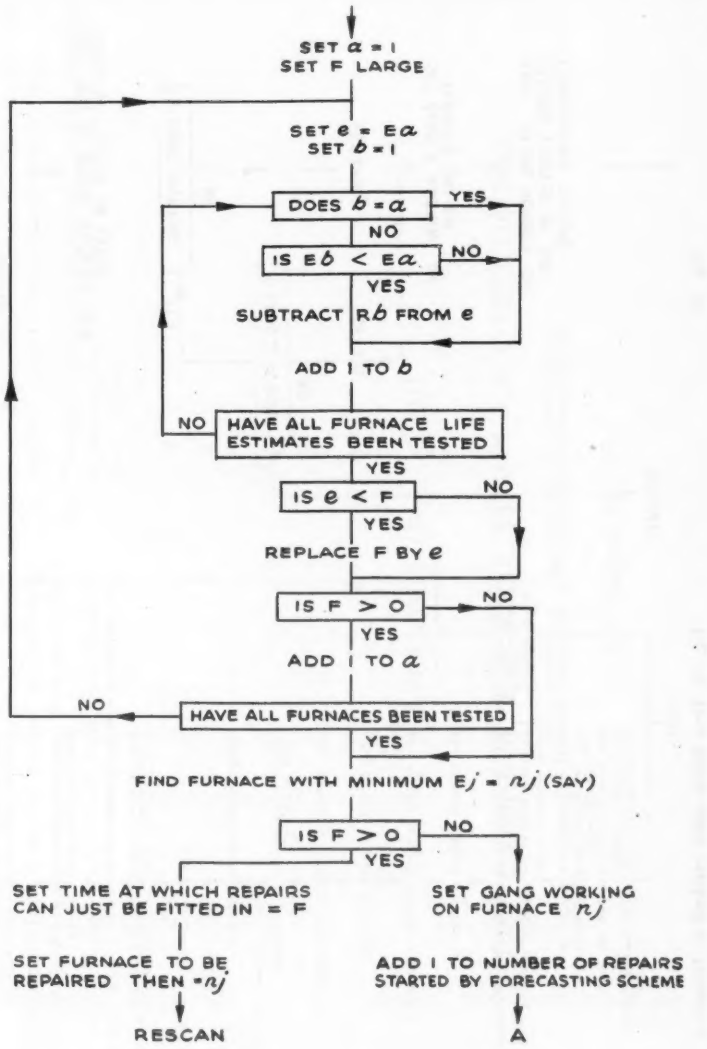


Fig. 16. Forecasting sub-routine.

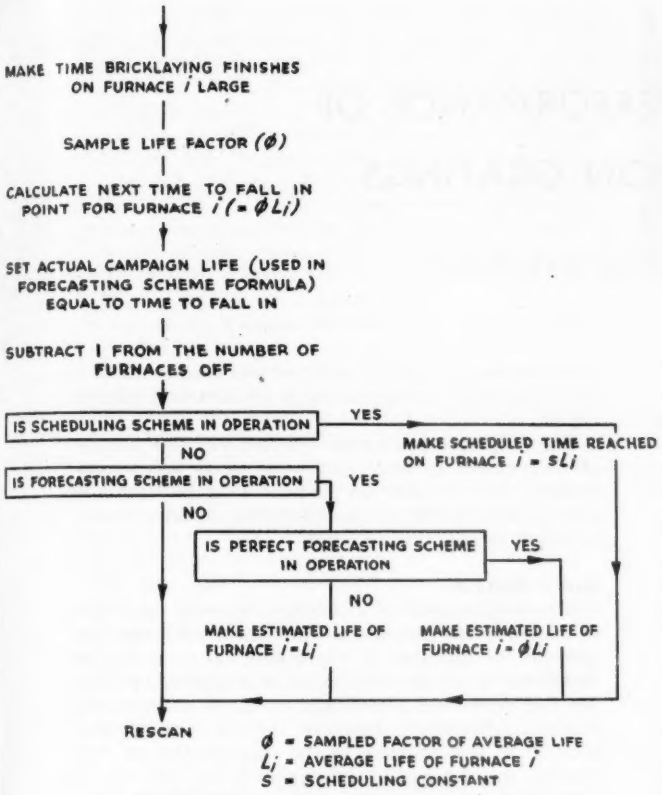

MAKE TIME BRICKLAYING FINISHES ON FURNACE i LARGE
SAMPLE LIFE FACTOR (φ)
CALCULATE NEXT TIME TO FALL IN POINT FOR FURNACE i (= φLi)
SET ACTUAL CAMPAIGN LIFE (USED IN FORECASTING SCHEME FORMULA) EQUAL TO TIME TO FALL IN
SUBTRACT 1 FROM THE NUMBER OF FURNACES OFF
IS SCHEDULING SCHEME IN OPERATION
YES
NO
MAKE SCHEDULED TIME REACHED ON FURNACE i = sLi
IS FORECASTING SCHEME IN OPERATION
YES
NO
IS PERFECT FORECASTING SCHEME IN OPERATION
YES
NO
MAKE ESTIMATED LIFE OF FURNACE i = Li
MAKE ESTIMATED LIFE OF FURNACE i = φLi
RESCAN
φ = SAMPLED FACTOR OF AVERAGE LIFE
Li = AVERAGE LIFE OF FURNACE i
S = SCHEDULING CONSTANT

Fig. 17. Time brick-laying finishes on furnace i.

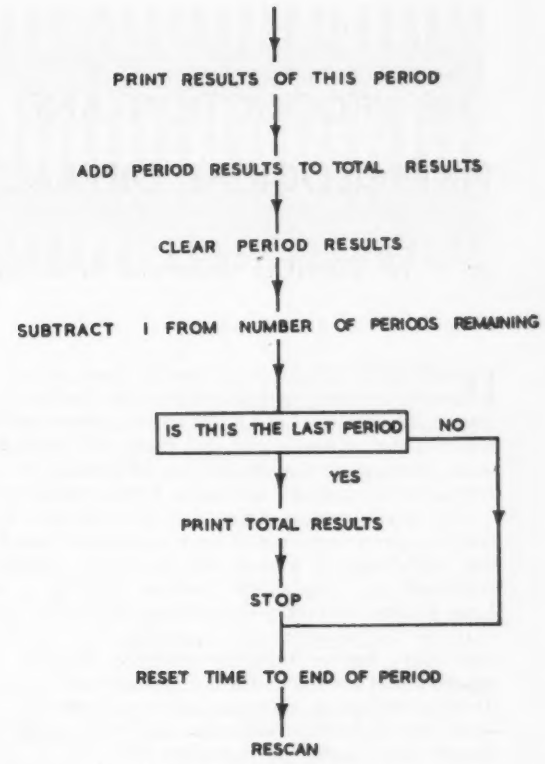
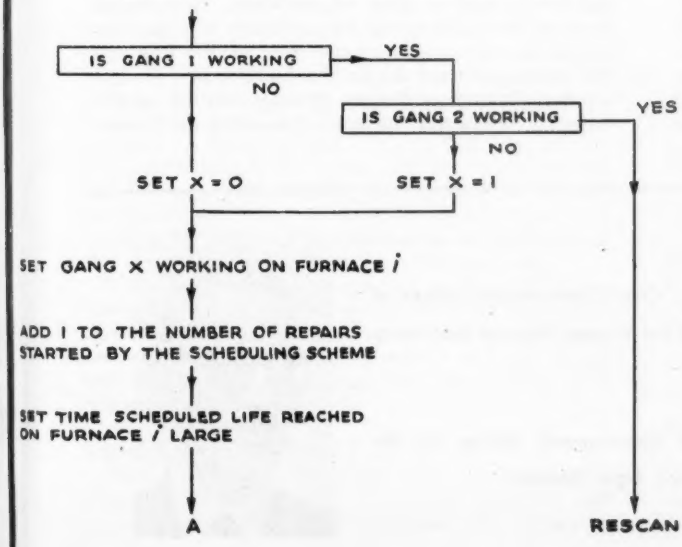


Fig. 21. End of period.

Fig. 18 (below). Scheduled life reached on furnace i.



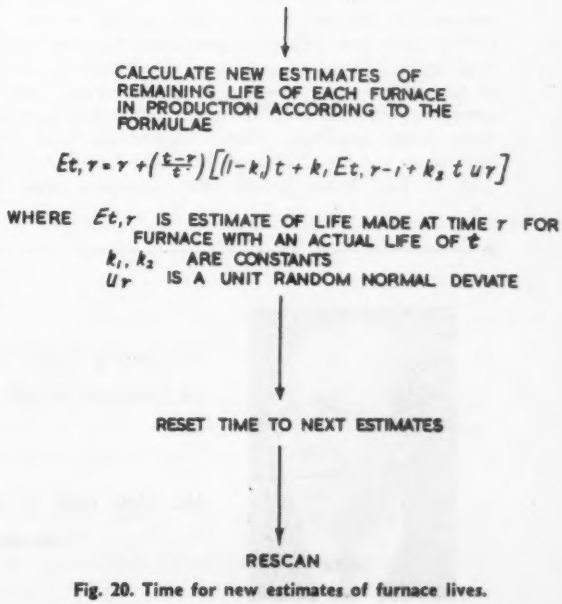

CALCULATE NEW ESTIMATES OF REMAINING LIFE OF EACH FURNACE IN PRODUCTION ACCORDING TO THE FORMULAE
$Et,\tau = \tau + \left(\frac{t-\tau}{t}\right)\left[(1-k_1)t + k_1 Et,\tau-1 + k_2 t\, u_\tau\right]$
WHERE Et,τ IS ESTIMATE OF LIFE MADE AT TIME τ FOR FURNACE WITH AN ACTUAL LIFE OF t
k_1, k_2 ARE CONSTANTS
u_τ IS A UNIT RANDOM NORMAL DEVIATE
RESET TIME TO NEXT ESTIMATES
RESCAN

Fig. 20. Time for new estimates of furnace lives.

THE PRODUCTION AND PERFORMANCE OF METROLOGICAL DIFFRACTION GRATINGS

by V. W. STANLEY, B.Sc. and R. G. N. HALL, A.M.I.Mech.E.

DIFFRACTION gratings are the basis of one of several modern methods of machine tool control; they have been used in an automatic contour milling machine for example and this Paper will include a short account of the application of gratings to the control of a standard tool room screw-cutting lathe.

For over a century diffraction gratings have been used by spectroscopists and have contributed much to our knowledge of atomic and molecular structure. Although they are simply surfaces bearing a very large number of evenly-spaced lines as grooves, there may be 130,000 grooves in a grating 5 in. in width and every groove must be perfectly straight and spaced to an accuracy of a few millionths of an inch. It is not surprising, therefore, that until recently they have been scarce and expensive and their production should have taxed the ingenuity and skill of many scientific workers.

About 12 years ago, however, Sir Thomas Merton suggested an entirely new approach to the problem of making diffraction gratings [1]. He proposed that a cylinder be impressed with a fine screw thread (or helical groove), coated after ruling with a uniform layer of self-setting plastic, and the resulting skin removed by slitting along a line parallel to the axis of the cylinder. When opened out flat the plastic pellicle, as it is called, replicates the thread as a series of parallel straight grooves, and this surface may be impressed on to a gelatine-coated glass blank to produce plane gratings. These suggestions have been developed by the National Physical Laboratory [2 - 6] and it has been found, for instance, that the gelatine gratings can be hardened and used as masters for preparing a large number of identical plastic copies.

These developments have led to a plentiful supply of inexpensive gratings and some years ago it was realised that in addition to producing gratings for spectroscopic work, scales of extreme accuracy were, in effect, being manufactured.

moiré fringes

The employment of diffraction gratings as scales of measurement presents an immediate difficulty for, whereas the divisions of a conventional scale can be identified by numbering, those of a grating are far too numerous and closely-spaced to be individually marked. Fortunately, however, there is a convenient solution to this problem in the superposition of two gratings to produce "moiré fringes".

For many years printers' screens of say 100 lines per inch have been tested by this method for equality of spacing by observations of moiré fringes, and some use has been made of such fringes in checking spectrographic gratings particularly for periodic or other repetitive errors of spacing [7 and 8].

If a grating is superimposed on another of the same spacing (see Fig. 1) and the top grating has its lines slightly inclined to those of the lower, illumination from the back will reveal fringes which run approximately at right-angles to the lines of the gratings. The spacing of these fringes is a function of the angle between the lines of the two gratings and the smaller the angle, the larger the spacing between the fringes.

Mr. Stanley (right) is a Chief Experimental Officer in the Standards Division of the National Physical Laboratory

Mr. Hall (left) is an Experimental Officer in the Laboratory's Light Division

If the top grating is moved along a line at right-angles to its grooves, a fringe will move to the position previously occupied by its neighbour when the upper grating is traversed a distance equal to one groove spacing.

If a slot of width less than half a fringe space and length say $\frac{1}{2}$ in. is placed close to the top grating, then as one grating is moved relative to the other, the passage of the fringes causes the illumination at the slot to fluctuate between brightness and darkness. If the eye is replaced by a light sensitive device such as a photo-cell the movement of the fringes can be electrically recorded and counted.

As the fringe spacing depends on the angle between the grooves of the two gratings, large magnification effects can be obtained. In practice the gratings are not in contact and therefore no wear occurs between them. Again, the length of the slot mentioned above will embrace about 1,000 grooves for a 2,000 lines per in. grating and so the position recorded by the photo-cell is the average determined by 1,000 lines of each grating. Local errors in the groove spacing or periodic errors of pitch sensibly shorter than half-an-inch are therefore averaged out.

The principle just described has been concerned with straight parallel lines, i.e., linear gratings, but the moiré fringe technique can be applied equally well to a grating of circular form for measuring angular displacement and in this case the lines radiate from a centre at equal angles. Such devices are known as radial gratings.

simple reading head

Although a pair of coarse gratings readily demonstrates the formation of moiré fringes as described above, the finer gratings used in practice require a simple optical system for presenting the fringes to a photo-cell, such as is shown in Fig. 2. Only one long grating A, called the "scale" grating is necessary and the other B known as the "index" is a replica of about $\frac{3}{4}$ in. diameter. Light from the source C (a straight thin filament serves as a slit source) is collimated by the lens D and is diffracted by both gratings, collected by lens E and then brought to a focus at the slit F, which is arranged to select the correct diffracted order and the particular wavelength of light to which the photo-transistor G is most sensitive. A limiting slot H is introduced in the collimated light of the system and the spacing of the moiré fringes is adjusted by rotating the small "index" until only one fringe is visible at any instant. The insert to the left of Fig. 2 shows the arrangement of the fringes in relation to a part-sectioned slot.

When using coarse photographic gratings the photo-transistor, or light-sensitive device, may be placed against the glass of the "index" grating without employing an optical imaging system, although it will still be necessary to collimate the light falling upon the gratings.

signal from reading head

The intensity of the light varies approximately sinusoidally as one grating moves past the other, and a photo-cell placed behind the exit slit will produce an alternating current each cycle of which indicates a movement of one grating division. This current can be dealt with in one of three ways:

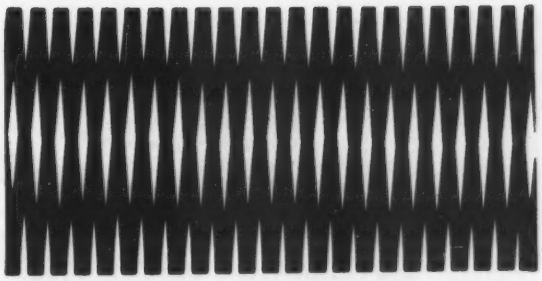


Fig. 1.

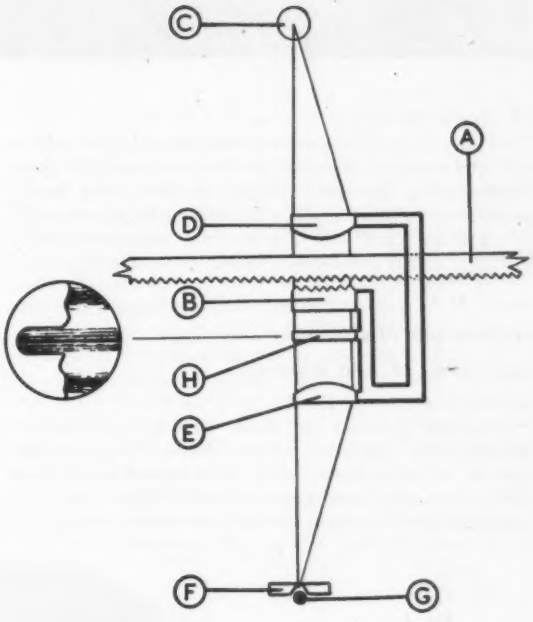


Fig. 2.

(a) *Analogue*

It may be fed into a phase meter and compared with a second alternating current derived from another grating system.[9]

(b) *Digital*

It may be used to actuate an electronic counter which simply registers the cycles of current and thus counts the number of complete spaces moved by the grating.[10 and 11]

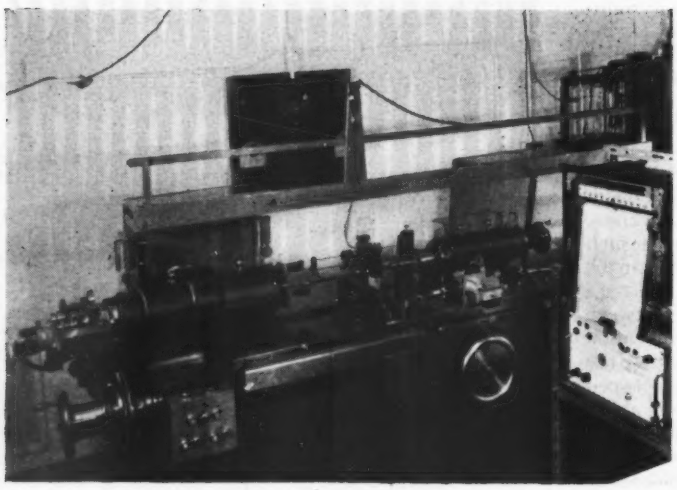


Fig. 3.

(c) *Digital-Analogue*

It may actuate a counter designed to indicate not only the number of cycles but also to sub-divide them continuously. By such means it has been found possible to measure grating movement to a hundredth of a grating space and thus to make measurements to 0.0001 in. with gratings of 100 lines per in.[13]

applications of gratings

generation of fine helices

(a) *Lathe performance*

Prismatic gratings are those manufactured by the Merton-NPL process which derive from helices having a groove form which is wedge-shaped. Such helices are generated upon a special lathe [12] and it is essential that the errors of this lathe should be known to a high degree of accuracy. A method has therefore been devised [14], for checking the performance of the lathe by means of the moiré fringe system and the grating used is of known accuracy and has 2,500 divisions per in. This grating, attached to the bed of the lathe, is used to measure the traverse of the tool-saddle while the movement of the headstock is indicated by a rotatory potentiometer.

Thus, with the lathe set to cut a helix of 2,500 threads per in., each signal from the grating is made to generate a "sampling pulse" to ascertain the instantaneous voltage of the potentiometer. If the performance of the lathe is perfect then each pulse derives the same voltage from the potentiometer, but in practice the variations of voltage indicate the errors of the lathe and can be applied to a chart recorder.

It was found by this means that repeatability of the position of the tool slide of the grating ruling lathe was not better than 0.00003 in. when check runs were made at the same pitch. Measurements of progressive error carried out for different pitches revealed much larger differences in the recorded errors, being of the order of 0.0001 in. Although useful gratings were produced after the initial work on the corrector bar, the lack of repetition alone made the gratings unsuitable for the best class of spectrographic and metrological work.

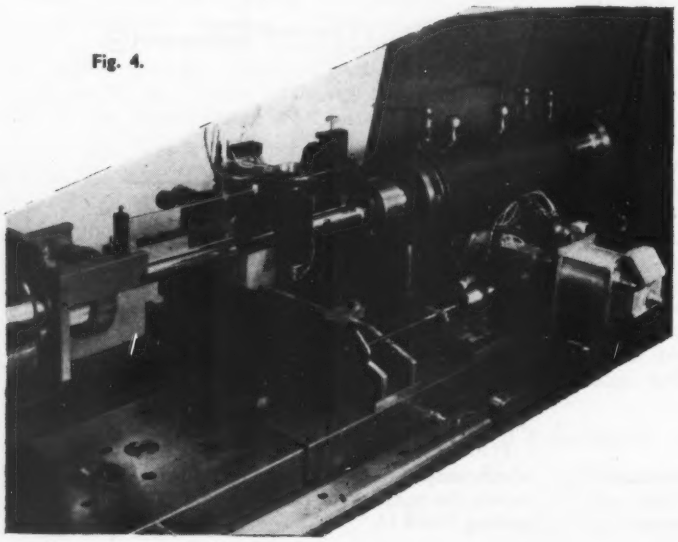


Fig. 4.

(b) *Lathe control*

Considerable improvements in the performance of the special lathe have been made by associating a servo-system with a reference grating with the machine, so that it is now possible to adjust the position of the tool relative to its slide whilst a helix is being scribed.

Before describing this improved control system which can be seen in the photographs (Figs. 3 and 4) some details are given of the preparation of the cylindrical blanks on which the fine helices are impressed. The helices are generally impressed on brass bars approximately 14½ in. overall length with a central parallel portion 12 in. long × 1 in. diameter. The cylinders are first ground to an accuracy of 0.0001 in. for parallelism and with a surface finish of about 0.5 micro in. They are then figured with an alginate lap using alumina abrasive and finally polished with a selvyt cloth lap using gamma-alumina. The surface finish should be specular and the straightness of any generator must be good to a few hundred-thousandths of an inch.

The impressing tool (a diamond lapped to a 90° Vee) is attached together with the scanning head to a plate mounted on the tool slide. This plate can be moved independently of the slide by means of a servo-actuated cantilever reduction system. The free end of the cantilever is operated by a spring and screw and nut controlled by a servo-motor, which takes its instructions from error signals obtained from the potentiometer on the headstock. The amount of correction applied is controlled by balancing the error signal against the voltage derived from a secondary potentiometer, also driven by the correcting servo. In order to provide a convenient comparison, this second potentiometer is returned to a zero position by another motor and switching is used to allow the motors to operate independently for each moiré fringe cycle.

Errors of the control grating can be allowed for by manually adjusting the zero of the headstock potentiometer as the scanning head traverses the control grating, which has been previously calibrated in position.[15]

Although the correction for errors is an intermittent process and it might be thought that the helix would have visible discontinuities, the errors at each sampling interval of say 0.0004 in., are in fact on the average about 0.000002 in. Also since the grating produced from the helix will be used with a scanning head, its local irregularities will be averaged out by the method of use.

normal screw cutting

(a) *Lathe performance*

The system just described refers to a lathe designed for producing screw threads of very fine pitches, and when using the servo system the thread on the workpiece is either of the same pitch as the control grating, or a simple multiple or sub-multiple of it. There are limitations to this technique because only one sampling pulse from the grating is received by the potentiometer in one revolution; this is obviously not suitable when cutting a screw thread of 10 threads per in. and using a finely spaced control grating. A method is therefore required for dividing the headstock rotation, and this is conveniently performed by placing a radial grating system on the headstock in place of the potentiometer and using a phase comparison technique for detecting positional errors.

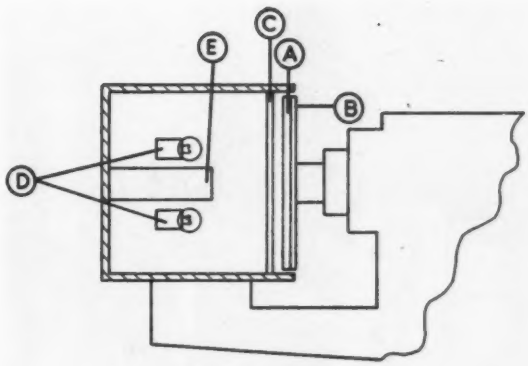


Fig. 5.

The radial grating arrangement is shown in the diagram (Fig. 5) and was designed as a reflecting system. The "scale" grating *A* rotates with the headstock and is backed by a white reflecting disc *B*. The stationary "index" grating *C* is concentric with and slightly clear of the scale grating and is illuminated by a pair of small electric lamps *D* placed to the rear of a photo-cell *E* viewing the combined gratings. The change in level of the illumination caused by transition from black to white can thus be detected and 100 complete cycles occur for one revolution of the work spindle. When cutting a screw of 10 threads per in. this corresponds to 0.001 in. travel of the tool slide and a 1,000 lines per in. grating is then used as a control; hence a signal is generated from the latter at every 0.001 in. The signals from the headstock radial gratings and from the linear control grating are sinusoidal and can be compared for phase. A change in phase corresponds to an error in travel of the tool relative to the rotation of the work, and a record of the combined errors of all the elements of the lathe between the spindle and the tool can be obtained.

(b) *Lathe control*

These measurements of error can be applied to a servo-system to correct the position of the tool at any instant. The photograph (Fig. 6) shows an experimental servo-system in a tool room lathe. The control grating and its reading head can be seen on the extreme right and the scanning grating is suspended from a block carrying the vertically mounted tool. This block is carried on the tool slide and can be moved parallel with the work axis relative to the slide by the transducer, seen on the extreme left, which is controlled by the phase comparator *via* a suitable amplifier. A departure from the initial zero phase difference will cause the transducer to adjust the position of the reading head and tool relative to the main slide and thus the phase difference is held to zero. Some work has been carried out on the lathe and the errors of the tool position were found to be reduced by using the servo-system from 0.0005 in. to 0.00002 in.

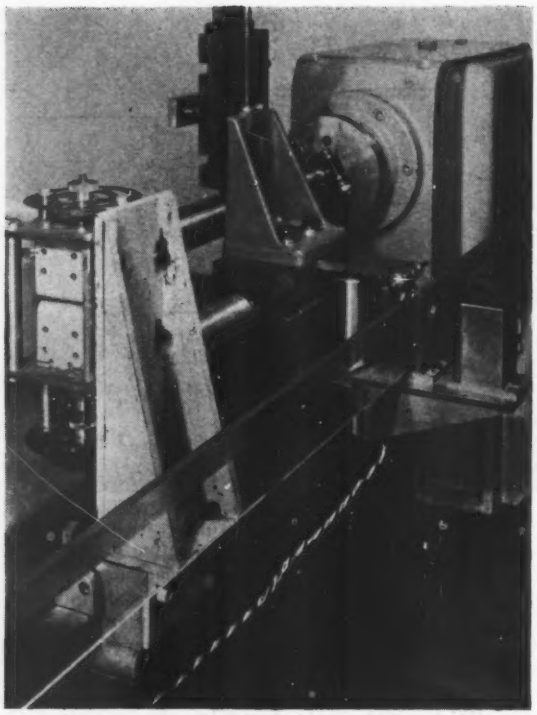


Fig. 6.

preparation of gratings

plastic replica process

The technique employed in the manufacture of a metrological grating from a helix has already been mentioned; its accuracy depends on the fidelity of a transfer process. Early work established the principles of making a replica of a flat grating and interferometric examination enabled direct comparison to be made between master and copy. When working with a cylindrical matrix, however, such intercomparison is not possible and the quality of an original ruling can only be inferred. It is of interest, therefore, to record that as a result of improvements to the ruling of helices a more detailed appraisal of the replica techniques has been made and the final grating used in the lathe control work, already described, had maximum errors of only $\pm$ 0.00003 in. on a 12 in. length. Evidence suggests that this accuracy will be improved.

Long lengths of grating may be prepared by casting in resin successive copies of one master (gelatine) grating end to end along the length of a glass blank. However, it is most important that each section of grating should be correctly in phase with the adjoining sections. Recent work has resulted in the application of a photometric technique of phase setting and by this means accuracies at the joints of approximately $\pm$ 0.00001 in. are possible.

When manufacturing long lengths of joined grating, considerable care must be taken to avoid curvature of the glass backing plate during the casting operation, otherwise sine errors will reduce the accuracy of the final article. It has been recent practice, therefore, to clamp the blank as each section is cast against a surface of optical quality, thus ensuring that if in subsequent use the grating is constrained to a straight line, each section will have the same inherent errors.

The overall length of a metrological grating may be adjusted by altering the angle of track across the grating lines [7]. It will be readily appreciated that at angles other than normal to the rulings a smaller number of lines will be encountered per unit length. For the purpose of providing a degree of control it is usual to arrange that the gelatine master has slightly more lines per unit length than the required plastic copy. A biassed or angled track (θ) is introduced when casting the final plastic copy and, in the case of a grating required to have 2,500 lines per in., the master would have 2,501 lines per in. and the angle θ is given by

$$\cos \theta = \frac{2500}{2501}$$

photographic processes

Lengths of grating up to 3 ft. long may be made by the above technique and the copy is of resin deposited on glass. At present it is not possible to derive one resin copy from another and therefore each long grating must be individually produced. Gratings up to 2,500 lines per in. may, however, be copied photographically and their corrugated surface subsequently re-copied by the resin process.

A description of this useful bridging technique has already been published [16]. Basically it consists of a long printing frame designed to hold a master grating and a photographic plate, with spacers between the two plates clear of the area to be printed. A collimated beam of monochromatic light passes through the master and the thickness of the spacers is chosen to bring the photographic emulsion into a region of maximum contrast. The light beam of $\frac{1}{2}$-in. diameter is traversed at a speed of 2 in. a minute, corresponding to each section of the sandwich being exposed effectively for 15 seconds. Any known errors in the master may be corrected for by swivelling the light beam, the angle through which it has to be moved being a function of the space between the two plates and the correction required.

The photographic grating consists of black and clear lines. By suitable exposure and processing the black lines can be made to corrugate the surface in the form of a sine wave. A replica of the surface in resin has somewhat similar properties to those of a prismatic grating and the fringe brightness is sufficient for use with any counting system.

The photographic process can be taken a stage further by using one of the previously mentioned copies and employing it to produce gratings of other spacings. In the apparatus shown in Fig. 7 the control grating and the photographic plate are sited in tandem on a single carriage. An index grating *A* in a scanning head produces moiré fringes from the control grating *B* and the unexposed photographic plate *C* is paired to another index grating *D* having the number of lines per inch required for the new spacing. If the slide carrying the grating and photo-

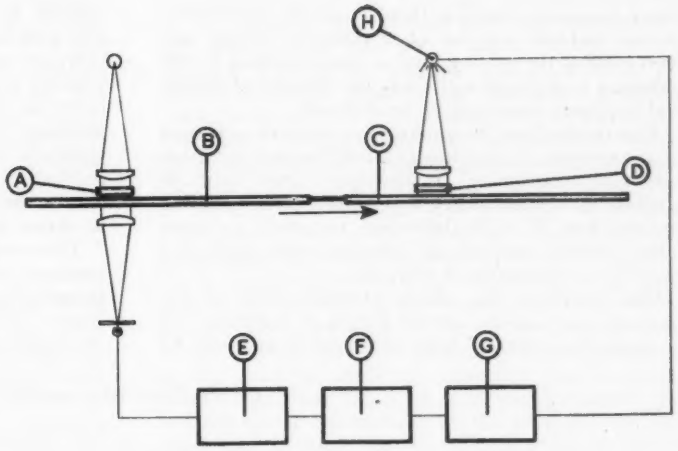


Fig. 7.

graphic plate is traversed, the signal transmitted by the photo-cell observing the fringes given by the control grating and scanning head can be passed to an amplifier *E*, through a phase-shifter *F* and thence to a trigger unit *G* containing suitable dividing circuits. The trigger unit can provide pulses at simple fractions, such as one in ten of the frequency of the original signal and may be used to operate a flash tube *H* arranged to image the printing-out index *D* on to the photographic emulsion. The plate, therefore, receives a large number of images each accurately positioned by the signals from the control grating, for example, at intervals of 1/1000 in. or simple sub-multiples 1/100, 1/50, 1/20 in., etc. The phase-shifter provides a means of correcting for residual errors in the control grating.

Coarse gratings produced in this way have been used by Technicolor Ltd. to produce 100 lines per inch reflection gratings on stainless steel tape up to 11 ft. long, the aim being to obtain an accuracy of the order of $\pm$ 0.0001 in. per ft. One advantage of the steel tape is that because the thickness is only 0.006 in. the grating is very near the neutral axis of the tape, and, therefore, sine errors are small. Consequently the flatness of the supporting surface to which it will be connected is not critical.

For many control engineering problems coarse gratings are adequate and accurate methods of fringe sub-division are actually in use.

measurement of grating errors

In essence a grating is merely a very fine scale or measuring device. It is, however, still subject to the faults and problems associated with more conventional measuring systems, for example, a line standard and its associated micrometer microscope.

Because of the interest in accurate measurement using gratings, the National Physical Laboratory are developing a universal test bench to provide the necessary calibration data for various types of grating and their associated systems.

To determine the errors in a metrological grating a knowledge is required of either the number of fringes and fractions that occur when the scanning head, or grating, is moved through an accurately defined distance, or the distance moved through for an integral number of fringes.

The apparatus as shown in Fig. 8 is set up to measure a grating against an end-standard. A pair of such standards can be used to provide an accurate interval and where overall length only is required provides a quick and efficient solution for calibrations. For such end-bar calibrations, the grating is held in contact with a ball-ended distance piece, the opposite end of which contacts the end-standard which comprises an end-bar with a slip gauge wrung to each end. The other end of the standard can be brought to the contact point of a precision dial indicator. It has been arranged that the centre line of the grating track, the standard and the fiducial indicator are aligned to minimise the effect of slide-way errors. The starting point of the calibration is obtained by moving the grating until a suitable reading is given on the dial indicator and the position shown by the

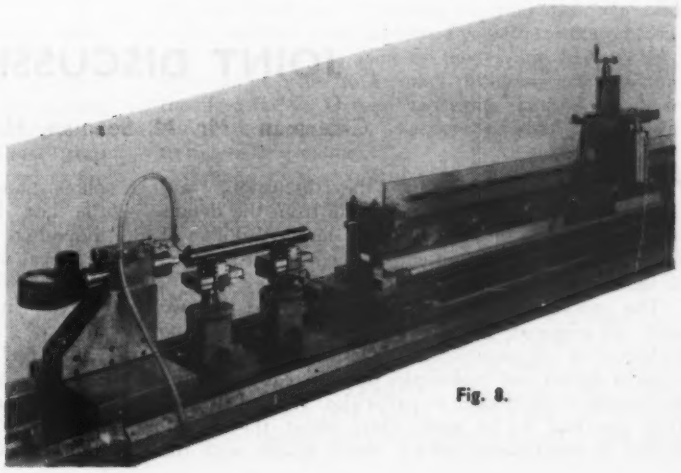


Fig. 8.

fringe counting system is then recorded. Substitution of the end-bar for one of a different length and then moving the grating until a repeat reading on the indicator is obtained will allow the number of fringes and fractions traversed to be deduced.

This method can be employed to calibrate a grating in, for example, 1 in. intervals but it becomes laborious and time-consuming; furthermore, time must be allowed for temperatures to equalise after handling the end-bars. It is the intention, therefore, to apply other methods for interval measurements which can be either comparative or absolute.

One technique by which determinations of the intervals and also the overall length of a grating can be made has already been described [15] and will be applied to this apparatus. In this case the indicator and end-bar supports will be removed and another carriage, carrying a line standard, mounted in tandem with the grating carriage. A photo-electric microscope is to be mounted from the base to view the line standard. A comparison can then be made of the intervals in the line standards with those of the grating. By recording the signals from the photo-electric microscope and the scanning head it is possible to obtain an automatic comparison.

The work described has been carried out under the guidance of Dr. L. A. Sayce as part of the research programme of the National Physical Laboratory. This Paper is published by permission of the Director of the Laboratory.

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JOINT DISCUSSION

Chairman: Mr. M. Seaman, M.I.Prod.E.

THE **Chairman,** opening the discussion, said that a big jump had been made from the details of control in the first Paper to the larger problem of organisation and computers applied to production in the second.

The problem that Mr. Greene posed was that we were all engaged, in one way or another, in some technical or organisational task affected by the new mass of details and techniques presented to us, at the beginning of the decade in particular. He had stressed that one had to be quite clear about the overall model of organisation which would square with the plans made for the application of these devices. In the last 10 years especially a large number of individual techniques, both in the theoretical and the practical sense, as well as new forms of control, had come forward.

They had not yet done the job of welding that mass of new techniques and devices into a whole with which they could handle the problem of management and activity. This had cropped up twice in the course of the Symposium. The main model of business activity with which they were concerned, and with which they could deal, could be stated in

this way: the series activity of business organisation really began with market research and the accompanying product research and development. This was quickly followed by the question of standardisation and simplification of the product components, and the coding that went with it. The massive control problem which arose must be solved through some number process. This was the material with which one dealt — the market, the items to be made, their control as a mass of activity.

essential body of knowledge

Jumping on further, one came to the way in which it was to be done. The Chairman preferred to simplify this and say that the essential body of knowledge was the whole programme of work study concerned with engineering, manufacture and distribution. There one had a model comprising, on the one hand, what one was going to do and the material with which one was to do it and, on the other, the way in which one was going to do it. What had been missing from many analyses was the belief that there was a logical connection between the two. This was established by operational research which, in the management field, was exactly the same as the feed-back, closed loop, in the purely physical sense. It related the item to be controlled, and the control, in a logical sequence so that one could predetermine behaviour.

From this visible model, to which one could look for the whole structure of business operations, flowed the matter of numerical control and data processing. It had been suggested that the model needed very much to be extended in one direction or another but it did provide for a large proportion of the total area of activity when one was looking at the problems with which one had to deal at first hand. If one accepted that this was what one was dealing with, and the linkages for dealing with it in management and initiative, data control became a by-product of it, and one decided how to use it for the purpose of control, which dealt with the whole number question on that side. This, with the examples quoted in Mr. Greene's Paper, was very much the sort of model one was striving for, and which the Symposium had been discussing.

The other big question, and this had been emphasised during the recent conference in Russia, was very much concerned with the steps being taken to link the computer directly with the production machines so that they were part of the process in a thoroughly logical way, not something apart from it. The N.P.L. had been very much concerned in the big step forward in Britain in the application of numerical control to machine tools. A considerable effort was observable in the rest of the world to link machine tools and other types of production devices with computers in this logical way — the signals for action on batch production had their reciprocal in measuring devices and quantity devices which told one the quality and quantity of the product passing through the factory at a particular time.

The Chairman had raised, the previous evening, the point that in applying numerical control to a full series of production there were modifications both in the design of the product and the machine tool and management side which were affected by this mode of thinking. An example was provided by the shipbuilding and construction industries. Members would be shown a film illustrating the fact that design was linked with computers and machines for manufacturing parts and, indeed, assemblies. They were witnessing a phase between pure number application of the kind seen in banks and insurance houses and the opposite end of the problem — manufacturing, where one was controlling large amounts of material whose ultimate physical form and combination were paramount and the numbers merely incidental to the process. The latter were, in fact, to be rejected except where they had a very high utility. The conjunction of the machine and the computer was emerging rapidly, but one ought not to underestimate the importance of the linkage of the computer at the other end, in programming, with the design aspect.

He would like for a moment to refer to shape and structures as a whole. The shape of ships, and structures generally, was developed from curvatures and forms, some of which were complex geometrically, in terms of empirically determined hydrodynamic, thermodynamic and aerodynamic tests. The problem was how to produce such shapes directly by devices which were postively controlled and inspected. It was felt that the shape of ships could be stated in three dimensions, according to known mathematical laws; that the three- to two-dimensional development could be made.

combining into one system

Programmes could be established which, poured into computers, would produce the magnetic tapes for the cutting of the two-dimensional shapes. Here one had the combination of design, manufacture, inspection, and series control of the material, organised into one system in what was basically a two-dimensional industry, so far as parts were concerned.

Similarly, on the manufacturing side, the carbon resistor provided an example in which the whole process from raw material to final product took place logically and numerically, with computer control. This was the kind of model one had to keep in mind in order to fit one's problems properly into the jigsaw. Mr. Greene had done them a service in giving them so many examples of that, and of the trends of the moment.

Equally in the control of machine tools, in particular, the question of direct monitoring, of inspection, accuracy and quantity was a vital, practical thing. Their other speakers had been concerned mainly with the root techniques of direct control of manufacture, and the link with the computer.

In the total picture of control the Russians were planning on a wide and intelligent basis. They had split their terminology to make it cover the various "orders" of automation. The first was semi-mechanisation — the series production of various items of linkage on the mechanical basis. The next

was full-series mechanisation of a complete product such as an engine block. The next was complex automation, as in the carbon resistor case. For the Russians the example was the piston manufactured directly from aluminium billets. Also their full, complex automatic production of things like ball bearings. Their plans included 50 complex automation projects in their next seven year plan.

The main difference between the Russian situation and the American and British was that, in general, the Russian plans were widely based. They envisaged bringing all the elements together and working for the solution, committing any amount of wealth, power, production and brains to it at the expense of the consumer market. This might tend in some cases to give them an advantage in a number of years inasmuch as greater standardisation was possible. Russia's population of 200,000,000, with that of China—600,000,000—and the markets of India and elsewhere encouraged this trend. Some quite surprising results might be obtained in 7 - 10 years. However, no one could buy the "know-how" involved in achieving the objective on the shop floor. The Russians had to pass through this stage just as had everyone else. They were at present seeking the answers to questions that had already been solved by our own N.P.L. companies.

Mr. J. Sealey (*Methods Engineer, Rotax Ltd.*) sought clarification concerning Mr. Greene's use of the word "computer", which he thought had been too general. What of automatic data processing machines, as distinct from computers?

Mr. Greene said that there were, of course, automatic data processing machines which were not computers. Broadly speaking, a machine could be called a computer if it had a large storage device and the ability to modify its own programme. Everyone was familiar with the ordinary Hollerith and I.B.M. punched card type, but this had not a large storage capacity which could be referred to in micro-secs., milli-secs. and so on.

Mr. J. Sargrove (*Automation Consultants and Associates Ltd.*) said that the digital computer was a serial machine which carried out calculations and took time in doing it. Often it was very much more complicated to do it that way than in parallel, with analogue computers which were often used for research purposes, or for stimulating an actual process in real time as the process progressed.

With a complex manufacturing process it was possible to use the process as a virtual simulator, with many transducers feeding in information from the machine variables to the analogue computer. This, in turn, produced corrective decisions right at the time one wanted them, and fed them back to the machine. In factories there was greater scope for this combination of analogue computers and machines than for the large digital computers and machines.

On the other hand, in overall control, where management was to be assisted, a digital computer which would give the numerical answers perhaps the next morning might be the right solution.

One might mention one or two practical examples. Ten or 15 years earlier no one would have dreamt of using electronically combined analogue computers and productive machines unless no other way existed to accomplish the task. In 1954 a problem had arisen concerning the production of submarine telephone cable for the R.F. carrier link between Britain and America. This had to be a coaxial cable on which one had to put a carrier wave in the megacycle frequency range. Variation in the cable characteristics resulted in cross-talk. The important factors were that, if the cable could be made infinitely uniform right along the ocean bed for 3,000 miles one would avoid cross-talk, and could put countless channels on the wire.

The economics had been studied at Dollis Hill for 10 years. It was thought necessary to have amplifiers every 60 miles, built into the cable, and the economics would be satisfactory only if at least 25 channels of modulation could be put on the single wire. Firms making extruded coaxial cables were asked to provide a cable accurate to a given tolerance and with practically no variation at all over lengths of 60 miles.

This problem was not like making ball bearings or roller bearings, where one could throw away even 10% and remain in business: failure to keep within the allowable variation of 0.1% would result in 60-mile lengths of cable being scrapped. To solve this production problem an attempt was made, he believed for the first time, to create an actual computer/machine combination. Those who had been connected with this venture were able to say that it had "paid-off" admirably. This was an "analogue" type of computer, but using some digital technical features, i.e., it was a very specified control-computer. He believed that more work should be done in this direction, so that the value of combination techniques would be realised, especially in processes where the absence of scrap was essential. Overall control also had to be proven and large firms such as I.C.I. would, he believed, make this kind of experiment and prove that it was possible

(At this point a film on machine control was shown. The **Chairman** conveyed the thanks of the meeting to Mr. C. F. Steventon and British Oxygen Ltd. for the loan of the film).

Mr. L. Webster (*Production Manager, Distington Engineering Co. Ltd.*) asked whether Mr. Greene know where practical use had been made of the computer in regard to production control, and also whether he knew of any general engineers, as opposed to large batch or mass producers, that were using it?

Mr. Greene replied that in answer to the first part of the question, there were several such firms. The first two had been computer manufacturers such as I.C.T. and I.B.M. in the United States. In the United Kingdom Pilkington's had it, Kodak almost had it, and Belling & Lee were going on with some form of

production and stores control. Others were British Timken in England and S.K.F. in the United States.

With regard to Mr. Webster's second question, Job White's, a small firm with 600 employees, had two years ago published a report on the subject. It had found that by spending £50 a week in hiring computer time it could solve its textile production control problems. This illustrated the fact that one need not buy a computer whenever one was needed. The practice of hiring time at a computer centre was spreading. The charge was approximately £30 - £35 an hour.

The **Chairman** said that British Oxygen's engineering factories manufactured a variety of small devices, ranging from 1,000,000 a year off, to the larger kind, with about 12 a year off. There were about 25,000 parts and about 10,000 start parts — raw material that was brought in and so on. Distribution control had been added to production control in the computer application. For instance, variations in sales estimates were linked with economic production batch analysis and the controls that went with it. The problem of queueing was being progressively overcome.

Mr. A. J. Lole (*Chief Methods Engineer, G.E.C. Ltd.*) said that the basic task seemed to be to reorganise the procedures in the factory so that they would feed information into the computer and thus provide the answers required. How long had it taken — months or years — to reorganise the procedures before using the computer?

The **Chairman** said that the studies had taken about three years. It meant establishing a total model of the whole picture, including distribution. Then both the organisation pattern and the procedures pattern began to fall into place. One could see the worth of the computer and proceed along logical lines. The warning about not proceeding with just one leg of it was very real. To deal merely with production control while large numbers of parts were being spawned in the design department was a waste of time. One had to pay great attention to the standard simplification and coding procedure. Then the whole team had to become computer-minded organisationally and technically. The right decision having been made, one proceeded along logical lines to apply it.

On the question of economic justification, if one had a complex electro-mechanical operation involving £2,000,000 a year total cost, one might have a fixed cost of £1,200,000 and an overhead of £800,000. The latter was made up of £400,000 which was pure numbers overhead, and £400,000 of technical overhead. One could, having taken the right model, prove up to the hilt that the cost of a computer was justified before ever starting work on it. This was possible because :

(a) pure number overhead costs were clearly isolated by procedure and were linked by management decision achieved and applied by the statistical techniques of operation research;

(b) technical overheads were activities in which technical judgment and initiative were effective; if control was linked to direct manufacturing processes large and constant savings were possible.

Mr. Greene said that the immense amount of preparatory work prompted the question as to whether it was worthwhile economically. A.E.C. Ltd., who were using an I.B.M. machine for production control, had had their experience reported in the Institution's Journal about two years ago. They had now been able to reduce their materials in store from £5,000,000 to £2,000,000.

Mr. Sargrove asked whether it would be possible to make diffraction gratings in the way that one made microgroove gramophone records — have a master, produce a chromium-plated model and then press them from that?

Mr. Hall replied that essentially the two techniques were very similar, but as each process posed its own particular problems the materials used in each case were different. N.P.L. gratings, unlike records, were ruled on metal cylinders and as had already been described they must be converted to a plane grating by the unwrapping of a thin plastic film. This plastic film, or pellicle, was used to produce hardened gelatine gratings, and it had been found that one of these could produce as many as 15 resin copies. Further, the same pellicle could be re-used, with care, to produce three gelatine masters and as the metal matrix would yield a great number of pellicles, the total of gratings that could be derived from any one ruling was extremely high.

Although there was a certain attraction in the idea of using a pressing technique, the number of copies required of a particular grating was never likely to approach that of a popular microgroove record. Also, it was difficult to envisage how a pressure technique could be applied in the case of joined lengths of metrological gratings, where each section had to be accurately phased with the adjacent one; there was also the hazard that glass was used as a backing to the thin layer of material containing the impression of the grating lines. It was true that each long joined grating must be individually produced and could at present be copied directly by a further resin casting process. However, the use of the photographic copy process (suitable for gratings up to 2,500 lines per inch) and the subsequent re-copying of their corrugated surface by resin was an effective solution to this difficulty.

Mr. K. J. Hume (*Reader in Engineering Production, Loughborough College of Technology*) asked : (a) how was it possible to maintain linear accuracy in the transfers, using relatively soft plastic materials and experiencing quite a deal of temperature variation? Also, he said that Mr. Stanley, when speaking of the high resolution gratings with several thousand lines to the inch, had referred to the geometrical form of the groove as producing a true physical optical

interference which produced, in turn, the moiré fringes. One seemed to get moiré fringes with the coarse gratings demonstrated, which were merely black lines or, presumably, photographic lines. He asked: (b) was there any difference in the optics of that method? If so, what was it?

Further, to what extent had the N.P.L. developed the use of coarse gratings, not merely in regard to counting discrete shifts of the moiré fringe but in measuring the phase displacement between one fringe and another, thereby being able to sub-divide the linear or angular division between individual lines. He understood that it could be done fairly easily on a continuously moving process, either circular or linear, where one could phase it electronically, but was there yet any means of doing it statically, as for a position control?

Mr. Hall replied that the production of accurate gratings was only possible by close attention to detail and technique throughout the entire process. However, with regard to the relatively soft plastic materials used, it was of course vital to ensure that such materials were in thermal equilibrium when actually transferred, and that such transfers were performed in a temperature-controlled solution.

The pellicle gelatine sandwich already mentioned was dried at 20°C and care was taken to ensure that any strains induced in the pellicle were removed before drying. It had been found that polystrene was the most suitable pellicle material. Further, the imperfections in the figure of the metal cylinder on which the ruling was made could influence the quality of the final grating. For example, a cylinder in which the generators were curved would produce pellicles which could be flattened and consequently the grating lines would not be straight. It was necessary, therefore, to produce cylinders with generators straight to a few hundred thousandths of an inch.

With regard to (b) in Mr. Hume's submission, there was no essential difference between the moiré fringes formed by a pair of coarse line and space gratings and those derived from very fine optical (prismatic) gratings.

It was easy to see, when using very coarse gratings, how a dark line on one eliminated the light passing through a space on the other (Fig. 1), but it must be realised that the fringe phenomena experienced with fine gratings was more complex and a full explanation was to be found in a book by J. Guild (Ref. 7). It was possible, however, to give a simplified explanation following the principle that a finely spaced diffraction grating produced a series of spectra from a parallel beam of white light. If, however, a parallel beam of monochromatic light was incident upon a grating, some of the light would pass straight through and the remainder would be split up and emerge at various discrete angles from the original direction. That portion of the beam emerging at the original angle of incidence was known as the zero order and the other beams, in progression from the zero were called first, second, third orders, etc. All these beams would act as incident rays of light on a second similar grating placed close to the first and would, therefore, undergo the same diffractions.

Consequently, if one considered the zero and first orders only, the zero order from the first grating on passing through the second grating, would give rise to two beams, one in its original direction and one in its first order. This first order was in the same direction as the first order emitted from the first grating and hence it would interfere with the ray which passed straight through the second grating, causing reduction or reinforcement of the brightness depending upon various factors, one of which was the relative positions of the grooves in the two gratings. If the gratings were inclined to one another, then across the width of the gratings the relative positions of the grooves would change and thus light and dark bands (the moiré fringes) would be formed. In practice it was not necessary to use monochromatic light; white light could be used and one portion of the resulting spectra selected by means of a slit, as indicated by F in Fig. 2.

The subject of fringe sub-division was of importance in deciding whether to use fine or coarse gratings. The divisions of a coarse grating could be sub-divided statically into 100 sub-divisions by the recently developed NPL-Stavely system. Using this system relatively coarse, though accurately spaced, photographic gratings could be used for most normal engineering requirements. Master gratings of this kind were being produced at N.P.L. and copies of these on steel tape were becoming available from Messrs. Technicolor Ltd. Briefly, in this system, the index consisted of four pieces of grating, each a quarter of a pitch out of phase with its neighbour. The variation of light intensity across these indices was detected by four photo-cells, one behind each section. The outputs of these were switch-sampled and integrated and the resulting wave compared in time with a standard frequency.

Sub-division of a fringe interval could be made by comparing the phase of the integrated wave form with that of the standard frequency, and this information could be presented either in analogue fashion on a phase-meter, or in binary digital form. Decade counters could be used to indicate whole grating spaces traversed.

Mr. D. Blakesley (*Head of Mechanical Development Dept., G.E.C. Applied Electronics Laboratories*) said that he thought he was correct in saying that in order to use moiré fringes, one had to count them. It was usual to use an electronic counter of the neon type used during the discussion. They were not renowned for their accuracy. There were two difficulties: the first was that one might miss a count. This was dangerous because one probably would not notice, and there was no means of checking. The second was that one had no absolute standard by which to check the final result. One was certainly dependent on the counting system.

Mr. Stanley, in reply, said that it was true, of course, that it was possible that the type of display unit used in the demonstration could miss a count, although

these units were reasonably reliable provided they were not required to function at or beyond their limiting speed. When Ferranti used this type of counter to indicate position, another dial was added to the counter in parallel with the last dial. This last dial was scaled in 12 divisions, so that a check on the counter could be obtained by dividing the number shown on the computer by 12 and then comparing the remainder with that shown on the additional dial. It would be obvious that these should agree.

On the other hand, these displays were merely visual indicators of a number of pulses. The pulse forming and detecting equipment was quite independent and whilst not perhaps infallible, was extremely reliable. Again, in the Ferranti Mark III system of automatic machining in three dimensions, the command tape had four channels; one channel to each of three dimensions and a fourth channel which provided a check on the sum of the pulses from all three dimensions. The mechanical design of the machine was such that the frequency of any vibration which would occur in the machine was lower than the maximum frequency of counting.

A system of measurement which did not embody a counter was that using Vernier fringes. Suppose one had a grating of 100 lines per inch and then superposed on this a 1 in. length of grating containing 101 lines with its rulings parallel with those of the lower grating, then one fringe would appear and this fringe would be parallel to the rulings. When the top grating was moved along the lower grating by the spacing of one line of the latter, the fringe moved from one end to the other of the top grating. Since the position of the fringe could easily be read to a tenth of an inch, it indicated the position of the top grating relative to the lower to at least a tenth of a grating space. Similarly, gratings of 10 and 1,000 lines per inch could all be mounted on one base and the gratings scanned by a reading head containing the appropriate Verniers, one for each grating. Thus position could be indicated without counting (see Ref. 8).

Mr. B. V. Barlow (*Chief Designer, Special Purpose Plant, S. Smith & Sons (England) Ltd.*) said that over the years he would often have used gratings if they had been available. He would hesitate to manufacture them in his own works. Were they now commercially available?

Mr. Hall replied that gratings ruled by the N.P.L. had been available through licensees to the process for a number of years and the gratings for spectroscopic and metrological purposes could be supplied by firms in London, Bristol and Newcastle upon Tyne.

As the N.P.L. retained the master gratings and only supplied licensees with pellicles or photograhic sub-masters, each firm had access to the same rulings. The cost of a grating varied from one licensee to another, but was determined usually, in the case of metrological gratings, by the length and number of joins.

Anybody interested in using coarse gratings on steel tape should approach Technicolor Ltd., who have developed plant and equipment to manufacture long lengths of this particular form of grating using master gratings supplied by N.P.L.

Mr. L. J. Blache (*Elliot Bros. (London) Ltd.*) asked whether he was correct in his impression that, in order to ensure that one did not lose a count, one used two reading heads and that the output of each was compared with that of the other. Also, could one use diffraction gratings to detect variation of inclination of one plate with another?

Mr. Stanley replied that a separate reading head was not required for the check dial on the neon type display but separate reading heads were necessary where fine and coarse gratings were used together. There was another simple method of using a grating to indicate position without counting fringes when a grating was used in conjunction with a screw. Suppose a grating of 2,500 lines per inch was used, then accurate indications of position at every 0.0004 in. were available. Assuming that the screw was accurate to about $\pm$ 0.0001 in., then the grating provided a calibration of the screw at every 0.0004 in. and the screw could be used to divide these small intervals and also indicate position.

It was possible to use gratings to measure the flatness of a surface using a parallel beam of light at oblique incidence. This was somewhat similar to the use of an optical flat in a Flatness Interferometer. But in the former case the distance apart of the moiré fringes indicated a change in height equal to the grating spacing and was not connected with the wavelength of the light used.

The Symposium then adjourned until the following day.

The Papers presented in Sessions II and III of the Cranfield Symposium on "Machine Tool Control Systems", will appear in the February issue of "The Production Engineer".

QUALITY AND ITS RELATIONSHIP TO THE DESIGN FUNCTION

by I. R. SMITH, M.I.Prod E.

Chief Inspector,
Bristol Aircraft Ltd.;
Member of the Institution's
Sub-Committee on Control of Quality.

REFERENCE to the Institution's Report on Quality* will show that at the head of each chapter an aim has been specified. The aim under the chapter headed " Design and Quality " reads :

Aim

> To create a specification which results in the optimum degree of inherent quality while permitting maximum economy in production.

The object of this article is to examine this Aim and postulate some method of achieving it.

It necessarily follows that it is not possible to lay down any hard and fast rules, since organisations vary in their methods of control and operation. Nevertheless, it is possible to lay down a series of principles which should be observed.

It must be appreciated from the outset that the specification referred to will range from a description of a requirement in written form, to detail drawings and performance schedules. In all these cases the basic need is the same, namely, the expression of a requirement to be translated into a physical fact by someone other than the creator of that requirement.

It will be readily agreed, therefore, that transmission of the requirement must be in a form that will enable the manufacturer to produce the end result to the satisfaction of the originator.

In accomplishing this end it is necessary for the Designer to be informed of the capabilities of the manufacturing equipment available and so ensure that the specification requirements are such that they are capable of achievement. On the other hand, it may be that newer designs would follow later technological developments and new capital equipment would be required.

* " Quality — Its Creation and Control." 10s.

Whichever is the case, it is essential that the manufacturing and design organisations work closely together.

customer satisfaction

This does not just happen; it is necessary for definite lines of communication to be laid down if this objective is to be achieved.

The creation of a product is the result of effort on the part of many people all of whose activities may vary but are integrated towards one end, CUSTOMER SATISFACTION.

The Designer must realise that when he creates the specification he is setting the quality standard. A loosely compiled specification will permit a wide variation in quality standard, a too tight specification will result in an unnecessarily high quality level which could prove uneconomic.

The Designer should endeavour to ensure that the level of quality required is that which at its lowest level satisfies the customer requirements.

The following questions could be asked :

Does the Drawing or Specification give clear and precise information of what is required and are all the factors present capable of being verified and repeated? The Designer must realise that as the originator he is first in line and is, by his design, issuing an instruction which others must carry into physical creation and, therefore, it is important that his requirements are stated in as positive and simple a form as is possible.

Does the organisation permit feedback of information on defects that have been found and difficiencies in operation?

This is where the Quality Group has a positive function to perform, since the results of investigations should be made known and acted upon.

The opportunity to comment at the initial design stage by all sections of the manufacturing organisation and other interested parties such as service and sales must necessarily lead to improved quality. It is at this stage that difficulties experienced in manufacture on previous designs and customer reactions can be fed into new design specifications.

A typical organisation is where the Design organisation has a policy committee of fairly high level, consisting of representatives from each interested department, with sub-committees who are specialists creating the specification for submission to the main policy committee. This type of organisation ensures that all possible consideration can be given to a specification before issue and thus introduce the preventative action mentioned in the previous article*.

It is at this stage that the Sales Department have an opportunity to comment on the economics of the product and so enable everyone to relate economics to the quality achievable.

It is at this stage that the Quality Department can inject the necessary thinking regarding gauges and test equipment that may be necessary and so ensure that Production Engineering make provision at the right stage.

Experience has shown the desirability of having someone in the quality organisation of the same calibre as the design side to make observations on design rather than criticising. By this means it has been found easier to introduce new thinking than had previously been possible.

The introduction of quality into design is probably one of the most difficult things to achieve and yet in practice it will be found that Designers are most anxious to ensure that quality is achieved. It therefore follows that here again we are faced with a programme of educating people to be quality conscious and selling the idea becomes one of the tasks of the Quality Group, since all aspects of quality are dependent on the human element.

* See December issue, pages 725 - 728.

Correspondence

From: **John M. Brice, M.I.Prod.E.,**
Divisional Director,
Rockwell Machine Tool Co. Ltd.

LT. HANCOCK'S letter in the November issue of *The Production Engineer* is not based on facts and it is therefore understandable that his conclusions are entirely wrong.

He states that the floor area taken up by machine tools at the recent Hanover Exhibition was some six times greater than that at Olympia. This is a gross exaggeration, the actual figures being as follows:

	Hanover	*Olympia*
Total stand area ...	503,800	287,200
Floor area used ...	861,500	430,000

Furthermore, one of the large halls at Hanover, whose floor and stand area are included in these figures, was used solely for exhibiting castings and not machine tools.

The vast exhibition facilities at Hanover (which were only partially utilised for the last Machine Tool Exhibition) are provided for German industry as a whole. I feel sure that the British machine tool industry and others would welcome and benefit from exhibition facilities in this country (for which public money could justifiably be used) on the lines of those at Hanover.

It is also worth while pointing out that the Olympia Machine Tool Exhibition is the only truly international machine tool exhibition in the world, whereas the comparison Lt. Hancock makes is with a German national exhibition, and obviously no logical conclusions as to the state of the British machine tool industry can be drawn from such a comparison.

His statement that "certain of the large British machine tool manufacturers no longer really need a factory, as they invariably offer a foreign machine in preference to a machine they make, or could make with a little thought and effort" is, to say the least, misleading, implying as it does that (a) the handling of imported machines by manufacturers is peculiar to this country and (b) British machine tool manufacturers are asleep.

With regard to (a), Lt. Hancock should know that parallel developments have in recent years taken place in Germany and the U.S.A. and are proving helpful to British machine tool makers by furthering their export trade.

Lt. Hancock should also realise that the design and production of machine tools is international, no one country having a monopoly of inventive genius and productive skill. To reduce imports, other things being equal, British manufacturers prefer to build machine tools under licence.

As for British machine tool manufacturers being asleep, this is surely disproved by the industry's constant growth (5,000,000 square feet of new buildings have been laid down since 1948), its order book of double that of a year ago and its continued success in overseas markets. In this connection it may be pointed out that over 50% of the orders received last year by our parent Company, Coventry Gauge & Tool Co. Ltd., for the "MATRIX" machine tools, were export orders.

However, members of the industry are by no means satisfied, and today there is a greater awareness than ever of need for continuous development. Activity and large expenditure in this direction are, however, not a result of late awakening but have persisted over a period in the history of the industry long enough to establish them as traditional. Furthermore, the industry, as is well-known, has now set in being a co-operative research organisation which is further proof of a forward-looking attitude.

THE ANNUAL DINNER, 1960

The 1960 Annual Dinner of The Institution of Production Engineers was held at the Dorchester Hotel, London, on Wednesday, 2nd November, 1960, and was attended by over 450 members and guests. The President of the Institution, Mr. G. Ronald Pryor, M.I.Prod.E., was in the Chair, and the principal guest was The Right Hon. Lord Piercy, C.B.E., Chairman of The Industrial and Commercial Finance Corporation.

During the evening the annual awards of the Institution were announced and the presentations were made by The Right Worshipful the Mayor of Westminster (Councillor R. L. Everest, J.P.).

The President, proposing the toast of "The Guests", said:

"JUST before I came to think about what I might say to you tonight I attended, with half-a-dozen others, a demonstration at a computerised office. I was bewildered by what I saw and by the jargon which I heard, but a wag in the party, finding that the computer had a keyboard input, spelt out on the keyboard 'why are we all here?' Like a flash the computer printed the reply 'because we're not all there.' (*Laughter.*) If you do not agree with some of the things that I am going to say, we shall have to get a super-computer to decide who is off the rails, you or I!

"In speaking to you from this chair last year I tried to give you some of the reasons why we all had such high hopes that the petition for a Charter, then before Her Majesty, would be successful. As you all know, our hopes were disappointed, but perhaps that was not altogether a bad thing. At any rate there is incontrovertible evidence that this failure, far from casting down our members, has stimulated them to even greater efforts, so that in due course, when we petition Her Majesty again, our record may be such that no chartered institution, however august and respected, will feel it advantageous to the nation or propitious to itself to lodge an objection. The Council are at present engaged on important considerations to this end.

the purpose of business

"I am more than ever convinced that the fulfilment of social responsibilities is the very purpose of business, and that invention, productivity and profit are only means, even if very necessary means, to this end. This, I submit, is the line our Institution can most profitably follow. Technologically we are travelling ahead at the speed of a jet plane, while socially we are still doddering along at the pace of an ox-cart.

"James Burnham's contention that the power in any community lies with those who control the means of production is a very plausible one and may well be true. In a communist or fascist State such power is in the hands of the government; in a democratic State it is in the hands of the industrial and agricultural managers. Surely the industrial managers have more than any other class the opportunity of learning how to handle men and women and surely, therefore, we as production engineers have a better opportunity than most people of attempting to change human nature? And, until human nature is changed, we have no chance of ridding ourselves of our present discontents.

false conclusions

"It is a false conclusion to relate these discontents to a political system, to contrast capitalism with communism, colonialism with nationalism. New systems are born, new classes come into being, new differences arise, and new friction points follow. It is a false conclusion to say that these discontents can be dispersed by increased productivity and a higher standard of living. The history of the middle-class during the last 20 years demonstrates that men whose material needs are satisfied are not necessarily superior men. Why is it that America, with a higher standard of living than ours, is not a happier nation? Why is it that, with some exceptions, the nations which are most highly developed industrially find it necessary to spend such a large proportion of their national income on the production of equipment to destroy their fellow men? Why is it that the industries which pay the highest wages are the most bedevilled by strikes? Why is it that we still have such a formidable refugee problem? Why is it that Sweden, whose national income per head of population is approximately a third more than ours, has the highest suicide rate of any country?

" Nor do I think that we shall get anywhere by accepting a conception which is being bandied about a great deal nowadays, the conception of organisational man, that man's greatest need is the sense of belonging to some group or other. I was very interested to note not long ago that Mr. John Marsh was of this opinion and put it very eloquently in his E. W. Hancock Paper.

" I believe that man's greatest need is a sense of achievement, of creation. Groups never create anything. They can develop an idea to a much greater extent than any individual, but the original conception always comes from an individual, whether a Marconi or Whittle, a Shakespeare or a Beethoven. Man is essentially an individual before he is a member of a group.

" It is high time that more of the best brains leaving our universities were spared from the technologies as generally understood and diverted to the sort of research that may involve problems of this sort, the sort of research which may eventually discover an antidote to the germs of hate and fear. It may be an act of faith to believe that this may come about, but it is an act of lunacy to believe that strife can be abolished by power politics, by economics or by productivity.

a fertile field

" It is, after all, men and women who make things tick. There are, fortunately, more and more signs of an increasing awareness of this amongst those whose whole background and livelihood is that of production and production engineering. I should like to refer here to the speech made by Mr. Wallace, Vice-President of the Massey-Ferguson organisation, at our North-West Regional dinner this spring, to the Paper by Mr. Stafford Beer, at the College of Aeronautics, Cranfield at our Summer School in August, and to our own Research Committee's Report on Quality. Here, then, is a very fertile field for the Institution to cultivate, capable of giving a very wonderful yield. The work cannot be done by our Council; it must be done in the Sections and the Regions, and I hope that they will devote a generous proportion of their programmes to it in the session, 1961 - 1962.

a distinguished company

" We have with us a very distinguished company of guests — the Institution guests, the prize-winners, my personal guests and members' personal guests. We are delighted that they have accepted our invitation and we sincerely hope that they are all enjoying the evening. I cannot possibly refer to them all by name and it would be invidious to make exceptions, but it is my pleasure and privilege tonight to introduce to you our guest of honour, Lord Piercy. (*Applause.*) I am particularly glad that he is able to be here, because he is President of The National Institute of Industrial Psychology, who are doing their best to tackle some of the very problems about which I have been talking, and he is also President of that sister body of ours, The Institution of Works Managers, with whom we have a good deal in common. For

The Right Hon. Lord Piercy, C.B.E. (left), the Institution's principal guest at the Annual Dinner, is received by the President.

15 years he has been Chairman of the Industrial and Commercial Finance Corporation. He is a member of the Court and Senate of the University of London and a Governor of the London School of Economics. As recently as July of this year, he took office as Chairman of the Wellcome Trust. He was Personal Assistant to the Deputy Prime Minister during the Second World War and has been a Director of the Bank of England.

" I have very much pleasure in proposing the health of our guests and in coupling the toast with the name of Lord Piercy." (*Applause.*)

The Right Hon. Lord Piercy, C.B.E., in response, said :

" My first duty and pleasure is to thank you, Mr. President, on behalf of the guests and myself for the kind remarks that you have made about us and to say how happy and honoured we are to be with you tonight. Next to that I should like to say that all of us hope very much indeed that the Institution will succeed in its next attempt to gain a Charter. We feel that nothing but good can result from the professional status of the production engineer being recognised and safeguarded by the grant of a Charter.

" My own training is that of an economist, and in my day the great topic of thought and research was the distribution of income. I am not going to talk about that, but production was really not much thought of in my time. One of our greatest economists, John Stuart Mill, said that nothing remained to clear up in the laws of production. The economist of Mill's time, of course, had no idea whatever of production technique. We used to learn a little about

The Annual Medal Awards, 1959

The Institution Medal for the best Paper presented to a Region or Section by a Member was awarded to Mr. S. G. E. Nash, M.I.Prod.E., for his Paper entitled "Metallic Materials and Process Development for Aircraft Applications".

The Institution Medal for the best Paper presented to a Region or Section by a non-member was awarded to Dr. W. L. Kent, J.P., for his Paper entitled "Management of Men".

The Lord Austin Prize for the best Essay submitted by a Graduate member was awarded to Mr. P. J. Varley, for his Essay on "The Selection and Training of Skilled Craftsmen".

The J. D. Scaife Medal for the best Paper published in the Journal of the Institution (other than those presented to Regions or Sections, or Named Papers) was awarded to Mr. C. J. Tanner, for his Paper entitled "Air Gauging — History and Future Developments".

The presentations were made by The Right Worshipful the Mayor of Westminster (Councillor R. L. Everest, J.P.).

the division of labour and go into the relative advantages of large- and small-scale undertakings, but that was about all. I suppose that John Stuart Mill would hardly have understood the meaning of cybernetics, and if I had been there I could not have helped him much. Perhaps, like the school-boy who was asked for a list of the major prophets and who offered instead a list of the kings of Israel, I might have offered to tell him something about automation, and there I should have felt safe, because I know what happens with the automation of sausage manufacture. The pigs go in at one end of the process and come out at the other as sausages. At the delivery point there is a man with an electric stove who cuts off some of the sausages and fries them to test whether or not they are satisfactory. If they are not he reverses the machine, and out come the pigs again at the other end. (*Laughter.*)

"Today, of course, in the economic field as well as others, production and productivity and a high and rising standard of living are all the go; but personally I must agree with your President when he says that the ultimate justification of productivity and production and everything else is a social purpose, and the fulfilment of social responsibility is the very purpose of business. We shall all accept that

> "We dig and heap, lay stone on stone;
> We bear the burden and the heat
> Of the long day, and wish 'twere done.
> Not till the hours of light return
> All we have built do we discern.

"The production engineer today is a very busy and hard-worked and sometimes hard-pressed man. The amount of technical equipment and knowledge that he has to have is tremendous, and, in spite of all these modern developments, he is a man who must keep his feet on the ground; he has to get the stuff out and he has to live up to very exacting standards. I remembered, when I was thinking about tonight, a saying of Carlyle's about production: 'Produce! Produce! Where it but the pitifullest infinitesimal fraction of a product, produce it, in God's name!'

"I do not think that the production engineer would get away with that. He has to turn out a definite volume of well-designed and marketable product, and his performance is going to be matched against costs and materials and work and, of course, the human factor, which can never be ignored. I have a quotation from the President of International Harvester, John McCaffrey, who, in an article entitled 'What Corporation Presidents think about at night,' wrote:

> 'The biggest trouble with industry is that it is full of human beings. The longer you are a president, the more firmly that fact will be riveted in your mind. That is why you will lose sleep.'

"Of all the elements that the production engineer has to combine and control the human factor is the most important. As your President says, it is men and women that make things tick.

"Among your guests tonight are men brought up in many different disciplines and serving in many occupations; but we all appreciate the value of looking a little beyond our individual daily limits. We can all, even though we may be ignorant of technology, appreciate the merit of getting the first-class brain of a technologist to do social thinking. It does us good to hear the kind of observations that the President has made to us tonight. Speaking for myself and, I am sure, for all the other guests, I thank you for a very pleasant evening." (*Applause.*)

acknowledgments

Mr. R. H. S. Turner, Chairman of Council, said:

"It is my bounden duty at this stage to make acknowledgments to those who have helped us wonderfully tonight to make this occasion possible. First, I wish to refer to Lord Piercy and to thank him very specially indeed on your behalf for his words of encouragement to the Institution and particularly for his reference to the human element. I am sure that that is something which the Institution can take well to heart, because the Institution is of no use whatever without the human element. The question of human relations and human management is of prime importance both to other Institutions and to ourselves, but particularly to this Institution of Production Engineers. I thank Lord Piercy very much indeed, therefore, for coming to this function tonight and for addressing us in the way he has. (*Applause.*)

"I want also to thank His Worship the Mayor of Westminster for gracing our function tonight and so kindly presenting the prizes. It is very pleasant to see the Mayor of Westminster with us and we are most grateful to him for finding the time to come; mayors, as we know, are very busy men. (*Applause.*)

"I feel sure that you would not wish me to overlook our very hard-working President, Mr. Pryor. He is a President who really takes his job to heart, and is a very worthy President of our great Institution. We look to him for a lead in our policy, and, by Jove! he gives it to us. We are very grateful to him indeed for the magnificent way in which he has presided at this function, and we look forward to continued leadership from him in his second year of office. Mr. President, we thank you most sincerely. (*Applause.*)

"I wish also to mention those responsible for organising tonight's function, our Headquarters staff, headed by our very worthy Secretary. They have been responsible for the arrangements for our comfort and entertainment, and I am sure you will agree that we owe them a debt of gratitude for their efforts. We thank them very much. (*Applause.*)

"On behalf of the Council, I thank all the members and their guests for supporting this function. I welcome the members here as old friends and I welcome their guests, whom we are very happy to see here. We are most happy to have you with us and look forward to seeing you again in the future. We wish you continued success in the meanwhile."

REPORT OF THE MEETING OF COUNCIL

Thursday, 27th October, 1960

THE second Council Meeting of the 1960 - 1961 Session was held at the Headquarters of the Institution at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 27th October, 1960. The Chairman (Mr. R. H. S. Turner) presided over an attendance of 31 members.

Before proceeding with the business of the meeting, the Chairman extended a cordial welcome to Members of Council who were attending for the first time. He also welcomed, as visitors, Mr. J. Aikman, Hon. Secretary, S.E. Region; Mr. D. S. Bone, Chairman, Luton Graduate Section; Mr. H. C. Knott, Chairman, Manchester Section; Mr. W. Silberbach, Hon. Secretary, Birmingham Section; and Mr. P. H. Steer, Chairman of the Brighton Group.

finance

The Council received the audited accounts for the year ended 30th June, 1960, and satisfaction was expressed that the budgeted surplus of 10% of income over expenditure had been achieved.

membership

It was reported by the Finance and General Purposes Committee that during the year ended 30th June, 1960, there had been a net increase in membership of 1,099 — the greatest annual net increase recorded in the history of the Institution.

The Council approved a number of applications for membership and transfer, details of which appear on pages 58 - 59.

The Chairman of the Membership Committee for 1960 - 1961 is Mr. J. A. W. Styles.

future Institution policy

The Council discussed at length a number of thoughts regarding the future policy of the Institution, which were put before the meeting by the President.

As a result, the Chairman was empowered to empanel a committee to investigate the whole matter of the Institution's future policy, bearing in mind the comments made during the discussion and to report back to the Council.

Aircraft Production Conference

It was reported by the Finance and General Purposes Committee that because of the major reorganisations taking place within the aircraft industry, the Southampton Section had decided that it would be inappropriate to proceed with their original plans for an Aircraft Production Conference in January, 1961. The Lord Sempill Paper, however, normally presented as part of the Conference, would be presented in London by Sir Percy Hunting, on 25th January, 1961.

National Conference, Brighton

It was reported that the National Conference on "Modern Trends in the Manipulation of Metals," held at Brighton in October, had been attended by 300 members and others, with their ladies. It was the unanimous opinion of those who attended that the programme of Papers was of a very high standard, and this was borne out by the fact that the Conference proceedings achieved outstanding publicity in the technical press.

resignation of Technical Officer

The Secretary reported that Mr. I. B. King, who had been the Institution's Technical Officer for three years, had resigned his appointment to return to industry. He had given the Institution most loyal service, and had made a notable contribution to the development of work in the technical field.

The Chairman said he felt sure that the Council would wish to add its appreciation of the valuable work which Mr. King had done for the Institution, and they wished him all success in his new venture.

education

It was reported by the Education Committee that during the period under review four courses had been examined, including a post-graduate diploma course in Industrial Engineering of the University of New South Wales, and exemptions for 11 Indian Universities had been formulated.

Discussions were being continued on the status of technicians coupled with the present position of the Higher National Certificate in Production Engineering.

The Chairman of the Committee for the 1960 - 1061 Session is Mr. W. Ainslie.

the Journal

The Editorial Committee were pleased to report that during the year ended 30th June, 1960, the

Journal had been produced at no cost to the Institution, despite the improvements and expansion brought into effect with the January, 1960, issue. The advertising situation remained satisfactory, and the expansion of the classified advertising section in the Supplement had been well received by members and affiliated organisations, who greatly appreciate this service provided by Headquarters.

The Chairman of the Committee for the 1960 - 1961 Session is Mr. John M. Brice.

Institution Papers

It was reported by the Papers Committee that the 1960 E. W. Hancock Paper, presented by Mr. John Marsh, Director of the Industrial Welfare Society, on "The Cult of the Self-Made Man", on 21st September, had been an exceptionally interesting Paper, followed by a good discussion. The Committee were very pleased that Mr. E. W. Hancock was able to attend this meeting, and to make the presentation to Mr. Marsh on behalf of the Institution. (*Mr. Marsh's Paper and a report of the discussion appeared in the December,* 1960, *Journal.*)

The Chairman of the Committee for the 1960 - 1961 Session is Mr. J. C. Z. Martin.

research

The following reports were received from the Research and Technical Committee :

Materials Handling Group

The Group Committee are discussing the possibility of holding a Convention in 1961, and draft programmes are being considered. The London Section Materials Handling Group had arranged a Study Group to run for six weeks commencing 25th October, at Headquarters, and a special lecture evening was being planned for April, 1961.

Computers and Production Control

The final draft of the report has now been completed.

Control of Quality

A series of articles on Control of Quality is being prepared and published in the Journal.

Co-ordination of Production Management Techniques

Work is continuing on this report.

In addition, it was reported by the Research Committee that the Working Party on Production Research Papers had recommended that there should be a separate publication for Research Papers, and that this point was being discussed with the Editorial and Papers Committees.

Discussions were also being held with the Ergonomics Research Society concerning the holding of a joint function on the Industrial Application of Ergonomics Research.

The Chairman of the Research and Technical Committee for 1960 - 1961 is Mr. R. M. Evans.

standardisation

It was reported by the Standards Committee that further discussions had taken place within the International Standardisation Sub-Committee on the necessity for including in the Institution's Examination Syllabus the requirement of a more detailed knowledge of the function and use of British Standards and International Recommendations. The Committee is also preparing a list of suitable references for possible inclusion in the Institution's "List of Recommended Textbooks".

One meeting of the Joint I.Prod.E./B.S.I. Standing Advisory Committee on the Use of Standards in Industry has been held during the quarter. The Associate Scheme for Standards Engineers has now been brought into being and a Programme Committee has been formed to arrange future activities.

The Chairman of the Standards Committee for the 1960 - 1961 Session is Mr. H. Stafford.

the Library

It was reported by the Library Committee that during the period under review, an unusually large number of overseas visitors (including several from the U.S.A. and U.S.S.R.) had used the Library for reference.

liaison with overseas Sections

The Vice-Chairman of Council (Mr. A. L. Stuchbery) in making his report said that visitors had come to Headquarters from Australia, India, Poland, Bangalore and the Netherlands. They had been particularly happy to welcome Professor Stanislav Sculz, a Member of the Council of the Polish Society of Mechanical Engineers, who had attended the Institution's Symposium on Machine Tool Control Systems at Cranfield, in August.

The visitor from the Netherlands was Herr Scherpbier, who had made arrangements for a representative to sit in at the Institution's Examination Board in order to study their methods.

The Council had approved the appointment of Mr. R. P. W. Curtis as the Institution's Corresponding Member in Rhodesia, and the Vice-Chairman had had the pleasure of meeting Mr. Curtis in London. At the present meeting, the Council approved the appointment of Mr. L. Walmsley, A.M.I.Prod.E., as the Institution's Corresponding Member in Malta.

The Secretary had also been visited during the quarter by Mr. Iyer, Deputy General Manager of Hindustan Machine Tools Ltd., who was playing a leading part in the establishment of the Institution's new Section in Bangalore.

1960 Schofield Travel Scholarship

The Council adopted the Finance and General Purposes Committee's recommendation that the 1960 Schofield Travel Scholarship, which for the year

in question is worth £750, should be awarded to Mr. J. S. Hawkins, Grad.I.Prod.E.

obituary

The deaths of the following members were recorded with deep regret:

Members:

S. Bramhall; J. A. Lucas.

Associate Members:

F. A. Bowen; W. H. Gee; K. L. Giare; Albert E. James; S. Majumder; Y. Tandan; N. A. Tucker; G. Parry Windsor.

Associate:

J. C. Jenkins.

next meeting

It was agreed that the next meeting of the Council should take place on Thursday, 26th January, 1961, at 11 a.m., followed by the Annual General Meeting, at 2 p.m., at 10 Chesterfield Street, Mayfair, London, W.1.

ELECTIONS AND TRANSFERS

27th October, 1960

BIRMINGHAM SECTION

As Member
F. H. Cooper.
As Associate Members
J. Tobin; C. N. East.
As Associate
A. W. F. Comley.
As Graduates
R. H. Dashper; B. C. Clarke; R. S. Dhaliwal; B. P. S. Cheema; M. A. Horton; J. Hudman; C. W. Hayward; D. W. Hadley; M. J. Lucas; B. G. Fisher; J. Garner; H. A. Edwards; C. Palmer; H. A. Clarke.
As Student
C. T. Clarke.
Transfers
From Associate Members to Members
W. B. Randle; J. D. Berry; E. Griffin.
From Graduates to Associate Members
R. C. Short; C. P. Round; A. E. Fell; M. D. Davis; R. Harvey; P. R. Bowen; B. J. Orr.
From Students to Graduates
N. Chakrabarty; W. H. P. McWhirter; P. H. Springer.

BOMBAY SECTION

As Members
G. K. Ogale; J. D. Daroga.
As Graduate
S. S. Yechury.
As Student
S. N. Bhargava.
Transfer
From Associate Member to Member
S. M. Patil.

CALCUTTA SECTION

As Members
H. Singh, M.B.E.; K. Mojumder.
As Associate Members
S. S. Jain; S. R. Dutt; S. N. Sinha.
As Students
N. Jain; M. Sen Gupta.
Transfers
From Associate Members to Members
S. P. Roy; H. P. Bhadury.
From Graduate to Associate Member
R. Datta.

CARDIFF SECTION

As Associate Member
J. H. Davies.
As Graduates
J. A. Leitch; B. Davies; K. Thomas; D. Lewis, J. C. Harry.
As Student
R. J. Bishop.
Transfers
From Students to Graduates
G. C. G. Knott; M. E. Condron; B. G. Moore.

COVENTRY SECTION

As Associate Member
F. Noblett.
As Graduates
E. Bishop; R. L. Williams; G. S. Harris; B. Shillcock
As Students
E. Minton; F. Pask; V. Hsia.
Transfer
From Graduate to Associate Member
K. L. Pickett.
From Student to Graduate
H. C. Harris.

DERBY SECTION

As Member
F. Nixon.
As Graduates
P. J. Browne; T. J. Cupitt; P. J. Thaxter; D. F. Halewood.
As Student
K. Cross.
Transfers
From Students to Graduates
R. J. McNeilly; J. Sinnott.

DONCASTER SECTION

As Member
H. H. Egginton.

DUNDEE SECTION

As Graduate
W. Kettles.
Transfer
From Student to Graduate
R. Lindsay.

EDINBURGH SECTION

As Associate Member
W. Scott.

GLASGOW SECTION

As Associate Members
G. W. McDowell; J. E. Perston.
As Graduates
W. D. Arthur; J. Wilson; J. Y. Muncie; C. Carey; D. Robinson; R. Gibbons; G. Napier; J. N. Harker; R. A. D'Silva; B. K. Biswas; J. C. Airth.
As Student
A. Taylor.
Transfers
From Associate Members to Members
A. E. Maver; J. H. Turner; A. H. Poole.
From Graduates to Associate Members
J. E. Scott; G. Stewart.
From Students to Graduate Members
D. Niven; D. M. Maitland; J. Crosbie; T. Mullen; A. A. W. Mitchell; P. F. J. Gallagher.

GLOUCESTER SECTION

As Associate Member
P. Black.
Transfers
From Associate Members to Members
A. D. P. Tallents; N. Curnock.
From Graduate to Associate Member
D. B. James.
From Student to Graduate
J. E. Cloke.

HALIFAX & HUDDERSFIELD SECTION

As Member
F. D. Drake.
As Student
E. Wilson.
Transfers
From Associate Members to Members
G. Butler; H. Bolton.
From Graduate to Associate Member
M. Dewhurst.

IPSWICH & COLCHESTER SECTION

As Associate Members
L. C. Rossiter; C. Leah.
As Graduate
J. M. Horwood.

LEEDS SECTION

As Member
G. Reeve.
As Graduates
M. R. Heffer; A. Cross.
Transfer
From Associate Member to Member
C. A. Nichols.
From Graduate to Associate Member
D. H. Blowers.
From Students to Graduates
R. A. Weston; A. Sayer; F. Burnett; J. D. Moore.

LEICESTER SECTION

As Associate Member
J. Smith.
As Graduates
E. G. Davis; P. J. Smart; P. J. Peasgood.
Transfer
From Student to Graduate
N. Hodgson.

LINCOLN SECTION

As Student
P. Page.

LIVERPOOL SECTION

As Graduates
R. Morris; D. Wilkinson; J. M. Wood; J. C. Wylie; N. Bagshaw; C. C. Butterwith; M. A. Gomm.
Transfer
From Graduate to Associate Member
E. Stockdale.
From Student to Graduate
C. Colquitt.

LONDON SECTION

As Members
G. R. J. Gatward; C. E. Browne.
As Associate Members
P. H. Mainprize; C. R. Warr; H. O. Rudloff; P. R. Fidler; K. F. Sherwood; L. Richardson; D. K. Corke; J. E. Clements; J. E. Garton; R. S. Fussell; B. Fergusson; L. N. Morris; F. L. Whittle; A. E. Hooper; I. A. Goble; A. E. Newman.
As Associate
F. M. de Bass.
As Graduates
D. H. Clark; R. R. Bridger; R. W. Day; C. Simmons; G. A. Goddard; C. G. Brand; R. W. Prizeman; V. E. Puckeridge; A. R. Bales; J. R. Trotter; R. R. Grenyer; A. J. England; R. J. George; L. A. Robinson; L. Y. S. Shum; J. F. Williams; E. H. Brooks; G. J. Gardner; B. A. Evans; P. W. Barnes; G. D. Paine; I. D. Frith; B. G. Cooke; K. A. White; S. W. Manning; J. Houghton; J. E. Willcox.
As Students
C. A. Bailey; M. G. Brown.
Transfers
From Associate Members to Members
L. W. Bailey; M. F. Avery.
From Graduates to Associate Members
R. H. A. Dean; H. Trubshaw; A. E. Bamberger; D. A. Monger; M. J. Lovell; E. J. Hathaway; **P. S. Catmur.**
From Students to Graduates
L. M. Sharp; R. J. Benson; R. Shannon; J. M. Leader; G. T. Flint; D. O. G. Clarry; D. V. **Poole.**

LUTON SECTION

As Associate Members
N. W. Sida; L. J. Warner; D. H. Rush.
As Graduates
E. J. Strange; D. T. Marsden; D. A. Sennitt.
As Student
E. L. **Amiss.**
Transfers
From Students to Graduates
K. R. London; D. F. **Lake.**

MANCHESTER SECTION

As Associate Members
E. Wilcock; E. D. Rees; J. Beard; F. L. Lee.
As Graduates
G. Gilbert; K. Muniappa; D. Johnson; N. G. Wallace; K. Wood; A. Warburton; A. G. Spencer; C. D. Sharangpani; G. Frith; N. K. Gupta; P. E. Hall.
As Student
B. Hunt.
Transfers
From Graduates to Associate Members
L. Wilson; S. Clare.
From Student to Graduate
G. Downing.

MELBOURNE SECTION

As Associate Member
L. J. Delaney.
As Graduates
G. E. Roberts; A. R. Morris.
As Students
P. E. Wellspring; R. W. Crooks.
Transfer
From Associate Member to Member
S. E. Green.

NEWCASTLE SECTION

As Associate Members
J. Cantrall; E. Toner.
As Graduates
I. M. Crowe; R. A. S. Dick; G. W. Taylor; P. J. Richards.
As Students
G. L. McElvoy; G. R. Cavanagh.
Transfers
From Students to Graduates
T. Bewsher; G. Blue.

NORTHERN IRELAND SECTION

As Associate Member
K. Simms.

NORWICH SECTION

Transfer
From Student to Graduate
D. J. Baxter.

NOTTINGHAM SECTION

As Associate Member
C. J. Beavor.
As Graduate
G. E. Orford.

OXFORD SECTION

As Graduate
E. J. T. Smith.

PETERBOROUGH SECTION

As Graduate
J. H. Ward.
As Student
S. H. Slack.

PRESTON SECTION

As Graduates
B. King; D. E. Whittles; A. L. Eccles; J. L. Birtwistle.
As Student
E. Stanway.
Transfers
From Graduates to Associate Members
A. Spence; A. Williams; F. Cunliffe.

READING SECTION

As Associate Member
D. M. Clark.
As Graduate
C. F. Nash.
Transfers
From Associate Members to Members
W. A. C. Carter; T. S. Aram; J. W. Barrow.
From Student to Graduate
G. R. W. Burrows.

ROCHESTER SECTION

As Graduates
P. R. Wesson; A. Stevens.
As Student
D. F. James.

SHEFFIELD SECTION

As Graduates
J. M. Hold; F. C. Payne.

SOUTH AFRICA SECTION

As Members
D. R. Inggs; F. J. A. Van Reenan.
As Associate Member
M. I. Anderson.
As Students
D. A. C. Jones; A. J. Marshall; A. Sawitz; H. H. Mitchell.

SOUTH ESSEX SECTION

As Associate Members
J. J. Weatherhogg; C. M. Hardwick; A. Miller.
As Graduates
J. D. Lane; J. Raymond; G. E. Greenwold; J. D. Parmenter; A. R. Turnbull; W. M. Mackay; D. J. Copeman; H. C. Butcher; J. A. P. White.
As Student
D. A. Paterson.
Transfers
From Associate Members to Members
S. R. Trevillion; J. Aikman.
From Graduates to Associate Members
C. C. Chorley; W. D. Shrubsole.
From Students to Graduates
T. J. Williams; R. G. T. Cook.

SHEFFIELD SECTION

As Associate Member
F. Avill.
As Graduates
R. A. Mathers; T. H. Archer; T. M. Hold; F. C. Payne.
Transfer
From Associate Member to Member
K. Walker.
From Student to Graduate
D. W. Cotterill.

SHREWSBURY SECTION

As Associate Members
C. Jones; T. M. Nickless.
As Graduates
W. Palphreyman; R. W. Langfield.
Transfer
From Associate Member to Member
G. M. Ranson.

SOUTHAMPTON SECTION

As Associate Member
E. H. Lapthorn.
As Graduates
G. H. Roberts; W. H. Roberts; A. Degg; D. J. Hammond; D. A. Lock; P. C. Knowles; J. K. Lee-Rand.
As Students
B. H. Drake; G. Hayward; D. W. J. Osbourn.

STOKE-ON-TRENT SECTION

Transfers
From Students to Graduates
J. Gilbert; T. J. Martin.

SWANSEA SECTION

As Graduate
D. G. L. Davies.

SYDNEY SECTION

As Graduates
J. L. Webber; J. Kedzier.
Transfers
From Associate Member to Member
H. H. Reid.
From Graduates to Associate Members
N. Williamson; N. E. Stott.
From Student to Graduate
F. C. Hitchen.

TEE-SIDE SECTION

As Associate Members
C. F. Ball; H. C. Ward.
As Graduates
K. R. Perera; K. Smith.
Transfers
From Associate Member to Member
R. Horn.
From Students to Graduates
P. N. Carter; T. A. Veitch; G. W. Stephenson.

WESTERN SECTION

As Associate Members
W. E. J. Lewis; F. E. Hargreaves.
As Graduates
G. B. Skipp; D. R. B. Young; J. H. Russell.
As Students
R. E. Hilliar; B. E. Jarrett; D. L. Giles; A. R. Wallington; S. K. Luk.
Transfers
From Associate Members to Members
H. J. Manners; J. R. Roberts.

WOLVERHAMPTON SECTION

As Associate Member
K. R. Hammond.
As Graduates
K. Dalby; R. Wise; A. G. Parkes; A. Hubbard.
As Students
R. B. Osborne; T. A. Hyde.
Transfers
From Associate Members to Members
F. W. J. Randall; J. R. Allan.
From Student to Graduate
K. G. Richards.

WORCESTER SECTION

As Graduates
M. B. Lister; G. E. Edwards; K. W. Haynes.
As Students
J. Chance; R. Rose.

NO SECTION

As Member
G. Monro.
As Associate Members
W. Teunissen; B. Grindrod; W. C. Jacobs; S. A. Warsi; M. G. A. Khan; S. R. Ghabrial.
As Graduates
L. G. Landrock; H. J. Brown; G. S. Jones.
Transfer
T. L. Wiseman.
From Student to Graduate

NEW AUSTRALIAN PRESIDENT

The new President of the Australian Council of the Institution is **Mr. Ian M. McLennan**, C.B.E., B.E.E., Director and Chief General Manager of Broken Hill Pty. Co. Ltd. He was formally installed in office by the outgoing President, **Mr. J. M. Steer**, at the Annual Dinner of the Melbourne Section on 11th November, 1960.

Mr. McLennan, whose Company is the largest single industrial enterprise in Australia, is Deputy Chairman of the Immigration Planning Council; Chairman of Council of the Australian Mineral Resources Laboratory; and Councillor and past President of The Australasian Institute of Mining and Metallurgy. He was awarded the Institute's Bronze Medal in 1960.

Mr. McLennan will be in England for three months in the Spring of this year, and looks forward to visiting the Headquarters of the Institution.

INDIAN GRADUATE AWARD

In order to encourage the preparation and presentation of Papers by Graduate members of the Institution in India, **Mr. T. R. Gupta**, Chairman of the Indian Council, will make an award of 250 Rupees every year for the best Paper presented during that year by a Graduate.

LONDON SECTION MATERIALS HANDLING GROUP

In accordance with its current aim to have a wide range of activities running in the area, the Group recently organised a Study Group which is meeting for one afternoon per week over six weeks to discuss various aspects of Materials Handling. The programme has been designed to allow for a free interchange of information between members of the Study Group in order that they may benefit from one another's experience.

The first session, which dealt with "The Scope of Materials Handling", was given by Mr. L. W. Bailey, M.I.Prod.E., Chairman of the Materials Handling Group in the London area.

Mr. A. G. Hayek, M.I.Prod.E., well-known for his early work in setting up the Group within the Institution and past Chairman of the Materials Handling Group Committee, gave the second lecture on "Methods of Analysis".

Subsequent lectures will be given by Mr. H. P. Mott, of Lansing Bagnall Ltd., on "Selection of Handling Methods", followed by Mr. L. J. Hoefkens, A.I.Prod.E., on "Stores Control Through Good Materials Handling".

The programme will finish with a talk on "Feeding Devices and Inter-process Handling" by Mr. G. Wittenberg, A.M.I.Prod.E., Rhoden Partners Ltd., and a case study by Mr. R. N. Barton, M.I.Prod.E., of Production Engineering Ltd.

Members of the Institution who would like further information on the activities of the Group should write to:

The Secretary,
The Institution of Production Engineers,
10 Chesterfield Street,
Mayfair, London, W.1.

The London Section Materials Handling Study Group in session.

Section Officers photographed with their guests at the Annual Dinner of the Sheffield Section held on 10th October last. Front row (from left): **Mr. R. S. Bruce, Sheffield Chamber of Commerce; Mr. G. Ronald Pryor, President of the Institution; Mr. H. Steel, Section Chairman; The Lord Mayor of Sheffield (Alderman H. Slack); Lord Aberconway; Mr. C. H. T. Williams, Master Cutler.** Centre Row (from left): **Mr. T. C. Firth; Mr. S. Caselton, Institution Deputy Secretary; Mr. H. Crompton, Regional Chairman; Mr. S. B. Rippon; Mr. W. F. S. Woodford, Institution Secretary.** Backrow (from left): **Mr. C. L. David, Leeds Section Chairman; Mr. J. G. Noble; Mr. R. W. Asquith, Halifax and Huddersfield Section Chairman.**

TECHNICAL OFFICER'S NEW APPOINTMENT

Mr. I. B. King, Associate Member, Technical Officer to the Institution for the past three years, has now returned to industry, as reported at the October Council Meeting.

Mr. King is now Gear Production Superintendent of Centrax Ltd., Newton Abbott, Devon.

DIARY FOR 1961

JANUARY 25	... ...	**The 1961 Lord Sempill Paper,** at The Royal Aeronautical Society, London. Speaker : **Sir Percy Hunting,** F.C.I.S. Subject : **"The World's Future Transport Requirements."**
JANUARY 26	... ...	**Annual General Meeting,** 10 Chesterfield Street, Mayfair, London, W.1.
APRIL 25	... ...	**The 1961 George Bray Memorial Lecture,** at Olympia, London.
MAY 24	... ...	**The 1961 Viscount Nuffield Paper,** at the University of Bristol.
NOVEMBER 1	... ...	**Annual Dinner,** Dorchester Hotel, London.

Sir CECIL WEIR,

K.C.M.G., K.B.E., D.L., M.C.

An Appreciation by

Sir WALTER PUCKEY.

The Institution has lost a wise and distinguished ex-President; I have lost an old and valued friend.

Sir Cecil Weir, whose recent death is mourned by so many of us, was a great man in the real sense of that term. I first met him during the war, when during his term of office in an important Government post, he attended a Conference at which I read a Paper. My recollection is of a small, fresh-faced, eagle-eyed man seeking me out afterwards, and expressing his appreciation in knowledgeable, warm, human words.

I was delighted, in the early post-war years, to sit under his chairmanship of the Dollar Exports Board, where his wise leadership, his wide acquaintanceship with overseas personalities, and his tireless energy impressed his colleagues and his contacts.

It was not surprising that he was chosen to represent the Government in Luxembourg as the head of the U.K. Delegation to the High Authority of the European Coal and Steel Community. In this important post he was required to exercise to the full his many human, business and linguistic qualities. The subsequent slow participation of the U.K. in European Organisation was, I believe, a disappointment to him.

In recent years we were closely associated in business, and I became even more intimately aware of those qualities which endeared him to so many people in all walks of life. It was, for instance, an education to see him walk around a factory; he would talk in the most human terms to almost every person he met, and this ability to develop a personal understanding was evident in almost everything he did. His reports of visits would contain many personal references; his approach to business problems was invariably through the personal requirements and satisfactions involved. He was always ready to offer assistance to those like myself who occasionally wanted help, and he never forgot to redeem his promises.

NEWS OF MEMBERS — continued

Mr. M. G. Ward, Associate Member, has relinquished his position as Senior Methods Engineer with G. Angus & Co. Ltd., Oil-Seal Division, Wallsend-on-Tyne, and has been appointed Chief Methods Engineer to the Mettoy Group of Companies, Swansea, Glamorgan.

Mr. C. J. Horseman, Graduate, has relinquished his position with Robert Stephenson & Hawthorns Ltd., Darlington, has taken up an appointment as Engineering Assistant, Shand & Jurs Section E.1., Whessoe Ltd., Darlington.

NEWS OF MEMBERS

Mr. A. I. Baker, C.B.E., J.P., Member, Chairman of the Baker Perkins Group of Companies, has accepted the invitation to act as Honorary President of the Engineering, Marine, Welding and Nuclear Energy Exhibition to be held at Olympia, London from 20th April to 4th May, 1961. Mr. Baker is also this year's President of the British Engineers' Association.

Mr. D. B. Bowen, Member, has now been made Sales Director of his present Company, Stanley Howard of Birmingham, where he was previously Sales Manager. Prior to this appointment, Mr. Bowen was for some 24 years Midland Area Manager for Messrs. E. H. Jones Machine Tools Ltd.

Mr. Ed. H. Holder, Member, has on medical advice advice returned to the United Kingdom from secondment to Pakistan Ordnance Factories at Wah Cantt., W. Pakistan, and has taken up duties as Principal Production Officer in D. A. W. (P.) Ministry of Aviation, St. Giles Court, London.

Mr. W. W. Jeacock, Member, has recently been appointed Director and General Manager of Pitter Gauge & Tool Co. Ltd., Woolwich.

Mr. J. D. Joy, Member, formerly Director and Deputy General Manager of Appleby-Frodingham Steel Company Ltd., is now Director and General Manager.

Mr. I. Mann, Member, has recently returned from India, and has taken up an appointment as Engineering Consultant, Home and Overseas, with The Carborundum Co. Ltd., Manchester.

Mr. T. A. Rose, Member, formerly of Taylor Woods Ltd., is now General Manager of Sydney S. Bird & Sons Ltd., Poole, Dorset.

Mr. J. W. L. Russell, Member, has been re-assigned from Calcutta to Singapore, as Assistant Managing Director of National Carbon (Eastern) Ltd., Singapore.

Mr. G. M. Beardshaw, Associate Member, has been transferred within the Tube Investment Group, to Raleigh Industries Ltd., Nottingham, as Works Manager of the Sturmey-Archer Division.

Mr. R. J. Broomer, Associate Member, has recently resigned his position of Assistant Technical Director with Messrs. F. J. Ballard & Co. Ltd., Tipton, to take up an appointment with Messrs. Stordy Engineering Ltd., Wolverhampton.

Mr. S. C. Das, Associate Member, has taken up an appointment as Lecturer in Mechanical Engineering Department, Indian Institute of Technology, Karagpur, S.E.Ry., India. Mr. Das has been staying in the United Kingdom and will be returning to India by the end of January, 1961.

Mr. B. Fraser, Associate Member, is now Applications Engineer at the Head Office and Works of Fletcher Miller Ltd., Hyde, Cheshire. Mr. Fraser was formerly Assistant Chief Manufacturing Development Engineer with the Guided Weapons Division of English Electric Aviation, Stevenage.

Mr. B. N. Ganguly, Associate Member, is at present in the United States for a six months' course on productivity subjects, sponsored by the Indian National Productivity Council in collaboration with the U.S.A. Technical Corporation Mission to India.

Mr. P. T. Hughes, Associate Member, has recently taken up an appointment as Senior Plastic Technologist with the Shell Chemical Co., Carrington, Manchester.

Mr. E. C. Nicholson, Associate Member, is now Chief Planning Engineer with Deans & Son (Yorkshire) Ltd., Beverley.

Mr. K. W. Smith, Associate Member, until recently a member of the Canadian Section in Toronto for nearly three years, and formerly with Alfred Herbert Ltd., Coventry and Calcutta, has now relinquished his position with The A. R. Williams Machinery Co. in Toronto, where he has been for the past eight years, to join Behr Machinery & Equipment Corporation, Rockford, Illinois, U.S.A.

Mr. H. Spencer, Associate Member, has recently taken up an appointment as Senior Lecturer in Engineering at the Ghana Technical Training College, Kumasi, Ghana.

Mr. W. K. Temple, Associate Member, Chief Engineer of the Newall Organisation, has been appointed a Director of The Newall Engineering Co. Ltd. Intimately associated with many of the Company's technical developments in the field of machine tool manufacture, he will retain his existing office and responsibility for direction of the Group's technical affairs. Mr. Temple joined the Company in 1946 as General Manager of the Peterborough factory and was appointed Chief Engineer three years later.

NEW BRITISH STANDARDS

Copies of the following British Standards, recently issued, may be obtained from the British Standards Institute, 2 Park Street, London, W.1, at the prices stated.

Addendum 1 to B.S. 292: 1958 **Extra precision bearings. 3s. 0d.**

B.S. 2960: Dimensions of 3-phase electric motors. B.S. 2960 Part 2: 1960 **Totally enclosed fan-cooled motors. 7s. 6d.**

B.S. 3228 Part 3: 1960 **Procedures for obtaining properties of steel at elevated temperature. Part 3. Creep strength. 3s. 0d.**

B.S. 3287: 1960 **Domestic electric clothes-washing machines. 6s. 0d.**

B.S. 3288: Insulator and conductor fittings for overhead power lines. B.S. 3288 Part 1: 1960 **Performance and general requirements. 5s. 0d.**

B.S. 3289: 1960 **Conveyor belting for underground use in coal mines. 5s. 0d.**

NEW AIRCRAFT STANDARDS

B.S. A.100: 1960 **Bolts and nuts for aircraft (General clauses). 10s. 6d. S.P. 89:** 1960 **Airframe bearings. 10s. 0d.**

REVISED BRITISH STANDARDS

B.S. 358: 1960 **Method for measurement of voltage sphere-gaps (one sphere earthed). 6s. 0d.**

B.S. 853: Calorifers for central heating and hot water supply. B.S. 853 Part 1: 1960 **Mild steel and cast iron. 17s. 6d. B.S. 853 Part 2:** 1960 **Copper. 20s. 0d.**

B.S. 1435: 1960 **Oil suction and discharge hose with built in conversion for test pressures of 100, 150, 200 and 225 lb./sq. in. 7s. 6d.**

B.S. 1732: Electric irons. B.S. 1732 Part 1: 1960 **Domestic irons. 5s. 0d.**

B.S. 1744: 1960 **Tests for agricultural tractors. 7s. 6d.**

B.S. 1853: 1960 **Tubular fluorescent lamps for general lighting services. 7s. 6d.**

B.S. 2629: 1960 **Pallets for materials handling for through transit. 6s. 0d.**

AMENDMENT SLIPS

The following British Standards have been amended by amendment slips (PD.) shown. To order quote PD numbers only.

B.S. 292/PD 3962; B.S. 600/PD 3932; B.S. 740/PD 3936; B.S. 796/PD 3945; B.S. 806/PD 3994; B.S. 819/PD 3957; B.S. 859/PD 3954; B.S. 924/PD 3946; B.S. 1102/PD 3944; B.S. 1363/PD 3908; B.S. 1549/PD 3965; B.S. 1768/PD 3968; B.S. 1784/PD 3948; B.S. 1862/PD 3910; B.S. 2083/PD 3949; B.S. 2560/PD 3959; B.S. 2769/PD 3970; B.S. 2782/PD 3978; B.S. 2814/PD 3909; B.S. 2845/Part 1 PD 3981; Part 2 PD 3982; B.S. 2885/PD 3953; B.S. 2930/PD 3935; B.S. 2960/PD 3952; B.S. 2901/Part 1 PD 3938; Part 2 PD 3939; B.S. 3030/PD 3933; B.S. 3128/PD 3980; B.S. 3251/PD 3934; B.S. 3300/PD 3951.

I.E.C. PUBLICATION

Publication 124 (First edition). Recommendations for the rated impedances and dimensions of loudspeakers. 6s. 9d. Postage 1s. 6d.

BINDERS FOR "THE PRODUCTION ENGINEER"

The Institution is able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six issues.

It will be found that copies of "The Production Engineer" can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference and handling of the volumes.

The binders may be obtained from: The Publications Department, 10 Chesterfield Street, Mayfair, London, W.1, price 10/6 each, including postage. Date transfers, for application to the spine of the binder, can be supplied if required, price 6d. each. (Please specify the year required.)

NOTICE OF ANNUAL GENERAL MEETING

NOTICE is hereby given that the Annual General Meeting of the Institution will be held at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 26th January, 1961, at 2 p.m.

AGENDA

1. Notice convening Meeting.
2. Minutes of the Annual General Meeting held on 28th January, 1960.
3. Report on Election of Members to Council [1].
4. Annual Report of Council [2].
5. Presentation of Statement on Income and Expenditure, Balance Sheet and Auditors' Report [3].
6. Election of Auditors, 1960 - 1961.
7. Election of Solicitors, 1960 - 1961.
8. Votes of Thanks.

By Order of the Council,
W. F. S. WOODFORD, *Secretary.*

1. See page 66 2. See page 67 3. See page 74

MINUTES OF ANNUAL GENERAL MEETING

held on Thursday, 28th January, 1960

THE Annual General Meeting of the Institution was held at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 28th January, 1960, at 2 p.m.

Mr. G. Ronald Pryor, President, was in the Chair.

Notice convening the Meeting

The Deputy Secretary (Mr. S. Caselton) read the Notice convening the Meeting.

Minutes of the Annual General Meeting held on 29th January, 1959

The Minutes of the Annual General Meeting held on 29th January, 1959 (published on pages 60 - 61 of the Journal for January, 1960), were taken as read, and on the motion of Mr. T. W. Elkington, seconded by Mr. B. C. Harrison, were confirmed and signed as correct.

Minutes of the Extraordinary General Meeting held on 30th April, 1959.

The Minutes of the Extraordinary General Meeting held on 30th April, 1959 (published on pages 61 - 63 of the Journal for January, 1960), were taken as read, and on the motion of Mr. G. A. J. Witton, seconded by Mr. C. T. Butler, were confirmed and signed as correct.

Report on Election of Members to Council.

On the motion of Mr. H. Burke, seconded by Mr. H. Unsworth, the Report of the Election of Members to Council was received.

Annual Report of Council

On the motion of Mr. H. W. Bowen, Chairman of Council, seconded by Mr. W. G. Ainslie, the Annual Report of Council (published on pages 64 - 71 of the Journal for January, 1960), was taken as read and received.

Statement on Income and Expenditure, Balance Sheet and Auditors' Report.

The President pointed out that an additional summary had been circulated giving the split-up of income and expenditure, and the assets and liabilities divided between the United Kingdom and outside the United Kingdom.

On the motion of Mr. H. W. Bowen, Chairman of Council, seconded by Mr. B. G. L. Jackman, the Accounts were adopted.

Election of Auditors, 1959 - 1960

On the motion of Mr. B. E. Stokes, seconded by Mr. H. G. H. Dixon, Messrs. Gibson, Appleby & Co., Chartered Accountants, were appointed Auditors to the Institution for the ensuing year, and thanked for their past services.

Election of Solicitors, 1959 - 1960

On the motion of Mr. R. N. Marland, seconded by Mr. J. L. Gwyther, Messrs. Syrett & Sons were appointed Solicitors to the Institution for the ensuing year, and thanked for their previous services.

The President said that the Institution had learned with regret of the sad death of Mr. Herbert Syrett, C.B.E., the senior partner of Syrett & Sons. He served the Institution for a great number of years, and those who had been members of the Council for a long time had got to know him very well and to appreciate his services. Mr. Bertram Cecil had taken the late Mr. Syrett's place.

Members stood in silence for a few moments as a mark of respect to the memory of the late Mr. Herbert Syrett.

Votes of Thanks

The President said his first very pleasant task was to thank the President for the year under discussion, The Right Honourable the Earl of Halsbury, for the great amount of work he did for the Institution, not only in travelling round the Regions and Sections and attending meetings at Headquarters, but also in many private meetings with persons holding high offices in sister Institutions, and learned counsel, in connection with the Charter Petition. The Institution was very fortunate indeed to have such an eminent person as Lord Halsbury as its President. Indeed, the Institution was fortunate in having a number of people who did voluntary work for it, and he desired to couple the vote of thanks with all the members of Council, the Chairmen and members of Standing Committees, the Chairmen and members of Regional and Sectional Committees, Honorary Secretaries, and in fact all those members taking an active part in the Institution; because the Institution just could not function without the great amount of time which all those gentlemen gave to its affairs. It was obvious from the progress which the Institution was making and the spate of applications from prospective members that a great impression was being made in the production engineering world.

The Institution was also very grateful to its permanent staff who served its members so well, headed by Mr. Woodford and Mr. Caselton, who was deputising so ably, and all the other first line members of the staff and their subordinates. It was with great pleasure that he proposed a hearty vote of thanks for all the assistance given to the Institution.

Mr. E. Percy Edwards said it gave him the greatest pleasure to second the vote of thanks.

The vote of thanks was carried unanimously, with acclamation.

Mr. H. W. Bowen moved that a hearty vote of thanks be accorded to the President, Mr. Pryor, for all the work which he had done during the year. Members looked forward to serving him in the ensuing year in the same way as they had done in the past.

The vote of thanks was carried unanimously, with acclamation, and the President then declared the meeting closed.

REPORT ON ELECTION OF MEMBERS TO COUNCIL

IN accordance with Article of Association No. 34, there were nine vacancies for elected members of Council (eight Members and one Associate Member).

For the eight vacancies for elected Members eight nominations were received, and the following Members were elected :

Major C. E. Darlington
Mr. P. G. H. Jeffrey
Mr. R. E. Leakey
Mr. J. G. Noble
Mr. P. J. Shipton
Mr. L. P. Simpson
Mr. J. W. H. Smith
Mr. J. H. Winskill

For the one vacancy for the elected Associate Member, one nomination was received. The Associate Member elected was :

Mr. G. V. B. Bevan

It will be observed that the numbers of nominations received equalled the numbers of vacancies and therefore no ballot was necessary.

REPORT OF COUNCIL

1st July, 1959 to 30th June, 1960

to be presented by the Chairman of the Council at the Annual General Meeting, Thursday, 26th January, 1961.

IT is with great pleasure that I place before you this Report of our Council's work for the past year and of our Standing Committees and their activities.

During the year under review, Mr. H. W. Bowen was Chairman of Council, and it was a very great personal pleasure to me to serve under Mr. Bowen as Vice-Chairman.

This past year has been a very important one for the Institution. In presenting this Report on behalf of all my colleagues, not only on the Council but on the Standing Committees to whom such a lot of our routine work is delegated, I should like to express the Institution's gratitude to all of them for their loyal support which they have given throughout the year.

1. Royal Charter

In this Report, I do not propose to go through all the circumstances which lead up to the disappointment resulting from the failure of the Institution's Petition for a Royal Charter. However, I think this most unfortunate set-back to our aim, if indeed it is unfortunate, has had the result of spurring us all on to still greater efforts. There is a great deal to do in the future because there are signs of much new thinking within the Institution, and during the period under review your Council has spent a great deal of time in considering future policy. It is now quite obvious that a vast majority of the membership were undismayed by the failure of our Royal Charter Petition, and many members have in fact written to our President assuring him that they intend to support the Institution with even greater vigour than they have done in the past. A fall-off in membership might well have been expected as a result of our failure to obtain a Royal Charter. This is far from being the case. In fact, during the year under review, the net increase in membership reached an all-time record, and I will be giving you statistics concerning membership later on in this Report.

2. the Secretary's overseas tour

At the instigation of Council, the Secretary of the Institution, Mr. W. F. S. Woodford, undertook an overseas tour which extended over a period of three months from January to April, 1960. This tour was undertaken as a result of proposals which had been made by our Overseas Councils and Sections. During this time Mr. Woodford travelled something of the order of 40,000 miles, and his journey took him through Israel, Persia, India, Singapore, Australia, South Africa and Rhodesia, and in all the places he visited, he was warmly received by officers and members of the Institution who extended to him the most generous hospitality. I do not intend going into detail concerning the Secretary's tour as members will have already read his Report, which was published in the October, 1960 issue of the Journal. The Report was presented to Council at its meeting held in July, 1960, and recommendations which the Secretary made have either already been acted upon, or are still receiving the careful consideration of your Council. I am sure that those of you who have read this Report will agree that Mr. Woodford has given an excellent account of what he has done, and will be certain that the visits have given great satisfaction to our officers and members overseas. Mr. Woodford is to be congratulated, not only for his Report, but on the excellent job he has done. Visits by the Secretary or any other of our senior officials are of paramount importance to the growth of the Institution's future relationships overseas, and your Council generally agree that as a result of the success of Mr. Woodford's tour, visits of this sort by the Secretary or any other chief official of the Institution, must be repeated in the future.

3. Ad Hoc Committee on organisation

In the last Annual Report of Council, mention was made of an Ad Hoc Committee which was set up " to review the implementation of the recommendations contained in the Report of the Committee on Organisation dated 1951, as modified by the Council, to consider their effectiveness and to make recommendations." As you are aware, I had the honour to be the Chairman of this particular Committee. The findings of this Ad Hoc Committee were drawn up in the form of a Report which was referred to all Region, Section and Standing Committees for study and comment. This Report, together with the comments, has now been submitted to your Council and accepted subject to very slight modifications. All the recommendations contained in the Report which were accepted by Council, have now been put into effect.

4. finance

The Institution's financial policy has absorbed a good deal of our time. As always, these affairs have been kept under the closest possible scrutiny by the Finance and General Purposes Committee. For several

years, both Council and the Finance and General Purposes Committee have been of the opinion that it was essential for the future well-being of the Institution that we budget for an annual surplus of 10% of our income. This surplus is required to enable us to make adequate provision for the Institution's future. To do this, as you well know, we had to ask the membership to accept an increase in subscription rates. I am very happy to report that this goal of 10% has in fact been achieved, and as you will see from the accounts, the excess of income over expenditure for the year under review amounted to £11,170. I think that you will agree with me that this result of our year's working is most satisfactory.

May I now direct your attention to the details of our Accounts which are published on pages 74 - 76 of the January, 1961 Journal. I do not intend to make any detailed comments on the Accounts at this stage except to say, and I think you must agree, that the figures are extremely encouraging. The adoption of the Accounts is a separate item on the Agenda, and you will have an opportunity then of asking any questions you may care to put.

5. Region and Section activities

I should like to refer to our Region and Section activities which have continued to flourish. There are now within the United Kingdom Regional Organisation, 38 Senior Sections, 12 Graduate Sections and a special Student Section at Loughborough College. Outside the U.K. we have our Australian Council with Sections in Melbourne, Sydney and Adelaide; the South African Council with its headquarters in Johannesburg, and the newly formed Indian Council with Sections in Bombay, Calcutta and Bangalore. We also have Sections in New Zealand and Canada. In addition to these organised Sections outside the U.K., we have also corresponding members in the Middle East, Malta, West Africa, Rangoon and Rhodesia and Nyasaland, who enable us to keep in touch with our thinly scattered membership in those areas.

The Regions and Sections have been very active during the year. In the U.K. some 300 meetings have been held, also a number of interesting works visits. In addition, many enjoyable social functions have been arranged. It is pleasing to record that a number of Regional events have also been held; among the more important were :

(a) The Seventh Conference on "Problems of Aircraft Production" held in Southampton in April, 1959.
(b) The North Midlands Regional Conference "The Production Engineer in a Changing Economy" at Derby in April, 1960.
(c) The Eastern Regional Conference "Production Engineering as a Function of Management" at Norwich in September, 1959.
(d) The Midlands Region Summer Meeting at Wellington, Shropshire in May, 1960.
(e) The London Graduate Section Tenth Weekend School at Dorking in October, 1959.

It is in the Regions and Sections that the great bulk of the Institution's professional work is done, and it is therefore, in our local Sections, both at home and overseas, that the strength of the Institution lies, and it is through these local organisations that our members can most readily maintain their contact with the Institution. The success of these local activities depends entirely upon the local Officers and Committees, all of whom are volunteers, and I should like to express to them all, the most sincere appreciation of your Council for their untiring efforts. In addition to the work of our local Officers and Committees, a very large number of members of the Institution give service in the Regions and Sections in numerous other ways, and the Council are very appreciative of these services.

The annual Conference of Region and Section Honorary Secretaries and Treasurers was held at Head Office in May last. At this Conference valuable discussions took place concerning administration and secretarial matters. I should like to make special mention here of the work of Honorary Secretaries as they are voluntary members of our organisation. I am sure you will support my remarks when I say that the Institution is most grateful to them for all the work which they do.

6. Summer Meeting

The President's Reception and Conversazione which took place at the Royal Festival Hall, London, on 27th June, 1960, was the first function of its kind to be arranged by The Institution of Production Engineers. Almost 500 members, their ladies and guests were received by the President of the Institution, Mr. G. Ronald Pryor and Mrs. Pryor. Your Council had hoped for a greater attendance at this function, but nevertheless, it turned out to be a great social success, and it is hoped to plan further functions of this sort in the future.

This event was combined with the 1960 Viscount Nuffield Paper which was given on the afternoon of the same day at The Royal Institution, when Sir. Stanley Rawson presented his Paper, "Machine Tool Development and the National Economy". Further details of this Paper are mentioned later in this Report.

7. Visitors from Abroad

We have been fortunate in welcoming to Headquarters a number of members who have been visiting the U.K. from other parts of the world. Members from the U.K. too, who have been visiting other parts of the world, have reported on the very warm welcome which they have been given. These personal contacts are invaluable in maintaining the strong sense of personal membership which is so important to the Institution and its members.

8. Polish Society of Mechanical Engineers

Over the past few years, the Institution has maintained a close liaison with the Polish Society of Mechanical Engineers and Technicians, and there have been several exchanges of visits between the two associations. The most recent visit of members of the

Polish Society of Mechanical Engineers and Technicians, which was sponsored by the Institution, was in June, 1960, when a party numbering 19 came to London. Their tour, which was arranged by the Institution, included visits to the Machine Tool Exhibition, Olympia, the National Physical Laboratory, Teddington, and the following Companies:

1. Fuller Electric Ltd., Walthamstow.
2. G. A. Harvey & Co. (London) Ltd., London.
3. Hoover Ltd., Greenford
4. Metal Box Co. Ltd., Rochester.
5. Power-Samas Accounting Machines Ltd., Croydon.
6. J. Stone & Co. (Deptford) Ltd., London.

In addition to the obvious educational value of these exchange visits, they are also of immense benefit in promoting good relations between the two countries, and on an individual basis many lasting friendships have been created.

9. Standing Committees

Although your Council is responsible for the government of the Institution, the day-to-day administration is much more the concern of our Standing Committees. We have a Standing Committee for each of our main branches of endeavour, with the Finance and General Purposes Committee as a kind of inner cabinet, the Chairman of each of the Standing Committees being a member of the Finance and General Purposes Committee. I should like, therefore, to give some account of their activities during the past year.

9.1 *Education Committee*

Mr. W. G. Ainslie was Chairman of the Education Committee during the year and the administration was the responsibility of Miss K. Allan, our Registrar at Headquarters.

The year under review has been a particularly busy one for the Committee largely in reviewing exemptions from Universities and Technical Colleges of the Commonwealth, and in studying the many important documents issued by the Ministry of Education dealing with the wastage of students in College courses and proposals for combating this.

A total of 65 courses has been submitted from 19 Universities and 24 Colleges. Very little of the work is routine and in several cases suggestions made for improving courses have been adopted by the educational institutions concerned. Degrees in Industrial Engineering from the Universities of New South Wales, Melbourne and Toronto, have been granted a considerable degree of exemption, but possibly even more pleasing has been the submission of Certificate and Diploma courses from such Commonwealth Technical Colleges as Ryerson (Canada), the Royal Melbourne, Swinburne and Footscray (Victoria, Australia).

Following the visits to India of Sir Walter Puckey, Mr. W. F. S. Woodford and Mr. F. W. Cooper, Education Officer, reconsideration was given to exemptions for degrees of Indian Universities. The Committee were indebted to their Chairman, Mr. Ainslie, for the production of a memorandum outlining recommendations for the type of degrees acceptable at specific universities. Discussion continues and it is hoped shortly to put the proposals to the new Indian Council. There is evidence too, that Indian engineers and industrialists are beginning to appreciate the importance of practical training.

In the U.K. a most interesting development in Technical Colleges has been the provision of short full-time post graduate courses in "Principles of Engineering Production". Such courses will at least give the young man graduating in more traditional engineering fields, an appreciation of production. The Committee also welcomed the two-year full-time course in Machine Tool Design at the Manchester College of Science and Technology, and also the Higher National Diploma course in Automation at Twickenham.

The following awards in Production Engineering were made in session 1958 - 1959:

Higher National Certificates: 635
Higher National Diplomas: 9

Two very important Ministry of Education documents, the Crowther Report "15 to 18" and the "Routes to National Certificate and City and Guilds Courses", were considered in detail. Both underline the wastage of students in part-time courses in Technical Colleges, and it can be anticipated that in the very near future, the Ministry will be issuing proposals for a drastic revision of entry conditions to National Certificate courses.

The brochure "A Career in Production Engineering" has, through the kindness of the Ministry concerned, been issued to Youth Employment Bureaux and Secondary Schools in the U.K. A special edition has been printed for Northern Ireland.

The Summer School, due to be held at Ashorne Hill in August, 1959, was unfortunately cancelled due to lack of support, but the Committee welcomed the formation of a Conference Organising Committee to consider a summer school at Cranfield in 1960, dealing with "Machine Tool Control Systems".

The Committee also welcomed an announcement by the National Council for Technological Awards of an award higher than the Diploma in Technology carrying the designation of "Member of the College of Technology" (M.C.T.). This Award will involve research in either industry or technical college for a period of about three years.

The Committee devoted much of its time to the consideration of the effect on National Certificate courses of the 1960 A.M. Examination, with particular reference to the place of mathematics in the Higher Certificate. Discussion continues on this, as also on the relation of the Institution to technicians.

The Education Officer has been enabled to pay visits to India and Poland. In company with Sir Walter Puckey, the Indian Science Congress in Bombay was attended, and several visits paid to Universities, Colleges and firms. Attendance at meetings of the Bombay and Calcutta Sections was most

fruitful, and a clear picture was obtained of the many difficulties besetting those responsible for academic and practical training. In Poland a visit was paid to the International Fair at Poznan, and a Paper on the "Education of the Young Production Engineer in the United Kingdom" was read to the Polish Society of Mechanical Engineers and Technicians by Mr. Cooper.

On a minor scale, the Education Officer visited two grammar schools in the London area to address a Parents' Association in one, and the Lower Sixth Form in the other. It is thought that such contacts with grammar schools are most valuable, and it is hoped that members will help the Education Officer to gain entry into their local grammar schools.

Examinations

There were 396 candidates registered for the 1960 examination, as against 492 for the previous year. (This figure includes those registered for the Joint Engineering Instiution's Part I examination.) These figures show continued growth of interest in our examination. The figure in 1959 was exceptional, since it was the last examination to be held under the old regulations, but the 1960 figure shows an increase of approximately 150 against previous years.

Education Discussion Groups

We have two Groups, one in London and one in Birmingham and they have both had an active year. Visits to a number of factories and Colleges were made and a number of lecture meetings arranged. The Groups have had active discussions on the effect which the recent changes in the Institution's examination are likely to have on National Certificate courses and some propositions were put to the Education Committee.

Schofield Travel Scholarship

The Schofield Travel Scholarship for 1960 was awarded to Mr. J. S. Hawkins. His project will take him to the United States of America.

Lord Austin Prize

The Lord Austin Prize for 1959 was awarded to Mr. P. G. Varley, a Graduate Member of the Rochester Section.

9.2 *Membership Committee*

Mr. A. Betts Brown was Chairman of the Membership Committee during the year, and the administration was the responsibility of Miss K. Allan, our Registrar at Headquarters.

A total of 3,207 applications for membership were considered. Of these, 1,886 were elected to membership; 625 were referred back for further examination requirements. The total membership of the Institution at 30th June, 1960, was 12,097, showing a net gain of 1,099 over the year.

The Membership Committee have been actively engaged in the preparation of the Practical Training Report, which will probably be published towards the latter part of this year.

Grades	*Membership Total at* 30.6.59	*Membership Total at* 30.6.60	+ *or* −
Honorary Members	7	7	—
Members	1,693	1,826	+133
Associate Members	5,381	5,478	+ 97
Associates	142	154	+ 12
Graduates	2,497	3,080	+583
Students	1,023	1,292	+269
Affiliated Organisations	255	260	+ 5
	10,998	12,097	+1,099

9.3 Hazleton Memorial Library

In spite of the fact that decorating operations interrupted the Library's services during what is normally the busiest period of the year, the Library dealt with approximately the same number of inquiries as it did last year; 4,117 inquiries were received and dealt with, and 4,496 books and periodicals were lent to members and to other organisations.

During the year, work was begun on a new supplement to the Library's catologue. This will list books added to the Library since 1955. The Committee began work on a history of the manufacture of the small electric motor, which will exemplify the development of metalworking process, and, thus, it is hoped, contribute to our knowledge of this history of production engineering. I should like to thank the firms and other organisations which have offered to co-operate in this project.

I must thank Mr. E. W. Hancock and several other members and friends of the Institution who have given the Library books and periodicals in the course of the year.

Mr. L. W. Bailey was Chairman of the Hazleton Memorial Library Committee during the year, and the administration was the responsibility of Miss M. South, B.A., F.L.A., the Librarian at Headquarters. Mr. L. W. Bailey retired from the Chairmanship of the Committee at the end of the year, having completed two years' service.

9.4 Research and Technical Committee

Mr. B. G. L. Jackman was Chairman of the Research and Technical Committee during the year, and the administration was the responsibility of Mr. I. King, our Assistant Education and Technical Officer at Headquarters.

This year certain new activities were initiated which I feel are worthy of note. In April, 1960, we had the opportunity of having Professor R. W. Shephard of the University of California to give a two-day seminar on Operational Research. This was followed in June by Professor W. G. Ireson of Stanford University, California, who ran a two-day seminar on Factory Planning. Both these functions were extremely well supported and brief reports have been published in the Journal. A similar function on Production Control was held at the Institution in conjunction with The British Institute of Management during October and November, 1959, and in this case, eight afternoon meetings were held.

The Sub-Committee on Computers and Production Control, under the Chairmanship of Mr. L. W. Bailey, has made good progress, and I understand that their report is now nearing completion.

Because of the considerable interest which has been shown in Quality Control, the Control of Quality Sub-Committee has been re-formed, under the Chairmanship of Mr. H. W. Mander. The Sub-Committee has undertaken to write a series of articles on the subject for publication in the Journal. Also in the Control of Quality field has been the Institution's participation in the annual conference of the European Organisation for Quality Control which, this year, was held in London under the auspices of the British Productivity Council. I am pleased to report that the Institution's President acted as Chairman at the Opening Session of the Conference, and also held a reception at the Institution's Headquarters for overseas visitors.

A further Sub-Committee has been studying the problems of "Co-ordination of Production Management Techniques", under the Chairmanship of Mr. A. P. Oppenheimer.

In addition to his administrative work, Mr. King has found it possible to contribute to the Journal a survey on Copy Turning.

Materials Handling Group

Much of the work of the Group has been concentrated on consolidating their position, and a further step forward has been taken by the setting up of a group in the London area with Mr. L. W. Bailey as Chairman; I know they will do everything possible to forward the Institution's interest in this field.

The Materials Handling Group is confident that it will be able to set up further active sections during the coming year, and these will be announced as final arrangements are made.

The Group maintains active liaison with other institutions and organisations having an interest in Materials Handling. The group represents the Institution on the National Joint Committee on Materials Handling and actively participates in a number of study groups, which this Committee has set up, namely, those dealing with:

(a) Factory and Warehouse Design.
(b) Road Transport.
(c) Costing of Materials Handling.

9.5 Standards Committee

Mr. R. E. Mills was Chairman of the Standards Committee during the year, and the administration was the responsibility of Mr. I. King, our Assistant Education and Technical Officer at Headquarters.

As in previous years, the principal work of the Standards Committee has been to comment on draft British Standard Specifications and to nominate Institution representatives to serve on B.S.I. Technical Committees. The Institution has representatives on some 140 of these Committees.

The Sub-Committee on International Standardisation, under the Chairmanship of Mr. T. A. C. Sparling, has been giving active consideration to International Standards Organisation Recommendations and has also given much valuable advice when the Institution was considering the adoption of the International Standard Paper Sizes.

The Joint Advisory Committee of the Institution and the B.S.I. on the use of Standards in Industry has held regular meetings. The Joint Committee organised a conference for Standards Engineers, the sixth of its kind, which was held in London, in May, 1960. Mr. R. E. Mills, Chairman of the Standards Committee, was Chairman of the Conference, which was attended by over 250 delegates. At this Conference it was agreed that the B.S.I. should set up an associate scheme for Standards Engineers, and they have been given Institution support on this matter.

9.6 Editorial Committee

Mr. B. E. Stokes was Chairman of the Editorial Committee during the year, and the administration was the responsibility of Miss M. S. C. Bremner, our Editor at Headquarters.

Under the Chairmanship of Mr. B. E. Stokes, the Editorial Committeee has continued its work of maintaining the very high standard of production and content of the Institution's Journal, now widely accepted under its new title of *The Production Engineer*. There seems little doubt that our Journal is well ahead of other publications in this particular field, and reflects a great deal of credit upon the Institution.

During the year the Institution's contract for the printing of the Journal was renewed for a further period of three years. We are fortunate in having printers who take a personal interest in the Institution's work, and we are indebted to Maxwell, Love & Co. Ltd. for their unfailingly helpful service.

The various changes of presentation which came into effect with the January, 1960 issue, including the new cover and title, aroused a great deal of gratifying interest, not least among our advertisers, whose demand for space continues to rise. Many congratulatory comments were received in connection with the June, 1960 issue, which was specially planned to coincide with the International Machine Tool Exhibition at Olympia, and which carried special advertising features.

Another successful development during the year was the introduction of semi-displayed advertising in the Production Appointments section of the Journal Supplement. Members will no doubt have remarked on the greatly enhanced appearance of this most useful service, which operates from Headquarters.

While it will be realised that the production of the Journal at its present high standard is largely dependent on the revenue accruing from the sale of advertising space, it is nevertheless one of the Editorial Committee's first cares to maintain an appropriate balance between the advertising and editorial content of each issue, and it is not anticipated that there will be any appreciable increase in the amount of space at present allocated to advertising.

Discussions have also taken place during the year, with the Chairmen of the other Standing Committees, regarding the publication of research Papers.

Institution affairs and personalities have continued to be well reported in the National and Technical Press, both at home and overseas, and there seems to be no doubt that appreciation and knowledge of the Institution's aims and activities is becoming more widespread.

I am sure you wish me to express to the Editorial Committee, and to Miss Bremner, the Editor and Press Officer, our appreciation of their excellent work and progress during the year.

9.7 Papers Committee

Mr. F. C. Cooke was Chairman of the Papers Committee during the year, and the administration was the responsibility of Miss M. S. C. Bremner, our Editor and Press Officer at Headquarters.

The principal task of the Papers Committee is to promote and maintain the supply of first quality Papers for the Journal, to make arrangements for the presentation of the Institution's Named Papers, and to adjudicate on the Annual Medal Awards.

One means of obtaining Papers of an adequate standard is by the promotion of Conferences, and during the period under review the Papers Committee, with the approval of the Finance and General Purposes Committee, started work on arrangements for a Symposium on "Machine Tool Control Systems", held at the College of Aeronautics, Cranfield, in August, 1960, and a National Conference on "Modern Trends in the Manipulation of Metals", which took place at Brighton in October, 1960.

During the year, 67 Papers and Theses were assessed, of which 41 were recommended for publication. The Committee is greatly appreciative of the help received in this work from the Corresponding Members elected by Sections throughout the country.

In addition to assessing material submitted, the Committee give much thought to the commissioning of Papers which it is considered would be of special interest to production engineers, and arrangements are being made to obtain authoritative material on the following subjects:

(a) welding of pressure vessels for reactors;
(b) production of tin plate;
(c) pressing;
(d) manufacture of optical lenses.
(e) mechanisation for small manufacturers.

Any further suggestions would be welcomed by the Committee.

Named Papers

During the year the following Named Papers were presented:

The 1959 *Sir Alfred Herbert Paper* was presented at The Royal Institution, London, on 10th December, by Dr. D. F. Galloway, M.I.Prod.E., Director of Research, PERA, who spoke on "Production Engineering Developments in the Soviet Union". The President of the Institution, Mr. G. Ronald Pryor, was in the Chair, and a report of the meeting appeared in the February, 1960, Journal.

The 1959 *Viscount Nuffield Paper* was presented at the Royal Technical College, Glasgow, on 17th March, 1960, by Dr. C. Timms, M.I.Prod.E., of The National Engineering Laboratory, who spoke on "Recent Developments in Spur and Helical Gears". This was the first occasion on which a Named Paper has been presented in Scotland, and a great deal of help in making the arrangements was given by the Glasgow Section. Mr. H. W. Bowen, O.B.E., Chairman of Council, was in the Chair, and a report of the meeeting appeared in the June and July, 1960, Journals.

The 1960 *Viscount Nuffield Paper* was presented at The Royal Institution, London, on 27th June, 1960, by Sir Stanley Rawson, who spoke on "Machine Tool Development and National Economy". The President of the Institution was in the Chair. (This formed a part of the Summer Meeting to which I have already made reference earlier in this Report.) This Paper and a Report of the discussion appeared in the October, 1960, Journal.

The 1959 *George Bray Memorial Lecture* was presented at the Federation of British Industries, London, on 1st June, 1960, by Mr. C. H. Bulmer, Research Department, P.A.T.R.A., who spoke on "The Packaging of Engineering Products". The President of the Institution was in the Chair and a Report of the meeting appeared in the September, 1960, Journal.

Medal Awards 1958 - 1959

The Papers Committee, having carefully considered the Papers eligible for the Awards, made the following recommendations:

The Medal for the Best Paper presented by a Member to Mr. S. G. E. Nash, M.I.Prod.E., of Bristol Aircraft Ltd., for his Paper on "Metallic Materials Development" (published in the January, 1960, Journal).

The Medal for the Best Paper presented by a Non-Member to Dr. W. L. Kent, J.P., of The Northern Aluminium Co. Ltd., for his Paper on "Management of Men" (published in the April, 1959, Journal).

The J. D. Scaife Medal Award for the Best Paper published in the Journal other than those presented to Sections and Regions, or Named Papers, to Mr. C. J. Tanner, of Solex (Gauges) Ltd., for his Paper on "Air Gauging — History and Future Developments" (published in the July, 1958, Journal).

The Committee reported with regret that they could make no recommendation for *The Hutchinson Memorial Award for the Best Paper presented by a Graduate,* no Paper eligible being considered of an adequate standard.

10. Honours

Her Majesty the Queen has been graciously pleased to confer honours on the following members of the Institution:

O.B.E. — Harry Bowley, M.I.Prod.E.;
P. M. Holman,
Affiliated Representative.

M.B.E. — A. S. W. Cannon, A.M.I.Prod.E.

11. Obituary

It is with deep regret that the deaths of 31 members have to be reported.

12. Headquarters Staff

It is always a pleasure to put on record appreciation of the invaluable work done by our Headquarters' staff. No one who has not come into contact with them as I have done can fully realise the extent of their qualities and their efficient enthusiasm for the well-being and growth of the Institution.

It is worth noting that despite increasing membership of the Institution, the number of Headquarters' staff remains constant. The growing volume of work is being well handled by taking every advantage of improved office techniques and management.

During the absence abroad of our hard-working Secretary, Mr. Woodford, Mr. Caselton, Deputy Secretary, took over the reins magnificently and did a first-class job of work. In fact he ably demonstrated how well served we are by our Headquarters' staff, who backed him up admirably.

Although it is not possible to mention all the members of the senior staff individually, who play such an important part in our organisation, I should like to pay tribute to Mr. King, who has served as our Technical Officer during the last three years, and to thank him for the pleasant and co-operative way in which he has carried out his duties. We all wish him well in his future industrial career.

In adding my personal thanks to all the staff for the work they do to enable me to carry out my duties, I must express on your behalf our special appreciation of the splendid way in which Mr. Woodford and his able team continue to serve our Institution.

13. The President

In the course of this Report, I have expressed the Council's thanks for the splendid work rendered by officers and members during the year. I now take this opportunity of paying tribute to our President, Mr. G. Ronald Pryor. All those who have had the privilege of personal meetings with our President cannot fail to be impressed with his vast knowledge of Institution affairs and his immense breadth of vision. His devotion to the Institution, and all it stands for, has been a great source of inspiration to the Council and the membership at large. During his period of office, he has travelled widely and attended numerous Institution functions all over the country. The more one knows of him, the more one becomes aware of his rare endowments. He has identified himself completely with the Institution, lived with it and for it, and it is in no small measure due to his untiring efforts, over many years, that the Institution has made such consistent and onward progress.

We are indeed extremely grateful to him for devoting so much of his time to the affairs of the Institution, from which we will get immeasurable benefit in the future.

In asking you to receive this Report of your Council for the year ended, 30th June, 1960, I do so with every confidence that you will agree that your Council have discharged their responsibilities conscientiously and effectively on your behalf.

I move that the Report be received.

THE BALANCE SHEET AND ACCOUNTS

FOR THE YEAR ENDED 30th JUNE, 1960

APPEAR OVERLEAF

THE INSTITUTION OF PRODUCTION ENGINEERS

BALANCE SHEET as at 30th JUNE, 1960

1959				1959			
	Accumulated Funds and Surplus				**Fixed Assets**		
25,000	The Viscount Nuffield Gift ...	25,000		35,000	Freehold Premises: at cost ...		35,000
500	The Lord Austin Prize Fund ...	500			Freehold Premises: Cost of Alterations and Equipment *less* Donations, Reserves etc.:		
100	The Hutchinson Memorial Fund	100			Balance at 1st July, 1959 ...	3,279	
500	The George Bray Memorial Fund	500			*Less* Receipts during year ...	39	
26,100			26,100	3,279			3,240
1,567	Life Subscription Fund		2,103		Furniture, Fittings and Plant at the net amount standing in the Institution's books at 30th June, 1948	1,531	
	Building Maintenance Reserve ...	3,896			Additions *less* Sales	13,044	
1,896	*Less* Expenditure during year	3,755				14,575	
			141	5,131	*Less* Depreciation	8,290	
37,357	Income and Expenditure Account		45,542				6,285
66,920			73,886		Fund Investments at cost: as		
201	Prize Funds—Accumulated Income		232	2,722	scheduled (Market Value £3,290)		3,656
	Current Liabilities			46,132			48,181
7,893	Sundry Creditors and Provisions	9,487			**Current Assets**		
351	Subscriptions Received in Advance	518		11,305	Sundry Debtors, Deposits and Stocks	16,277	
8,244			10,005	14,928	Cash at Bank and in Hand ...	16,665	
				3,000	United Building Society—Deposit (South Africa)	3,000	
				29,233			35,942
£75,365			£84,123	£75,365			£84,123

G. RONALD PRYOR, *President.*

R. H. S. TURNER, *Chairman of Council and Finance Committee.*

W. F. S. WOODFORD, *Secretary.*

Report of the Auditors to the Members of The Institution of Production Engineers

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account ha been kept by the Institution so far as appears from our examination of those books. Audited Balance Sheets and Accounts have been received from each of the Councils and Sections outside the United Kingdom with the exception of the Canada Section and these have been incorporated in the above Balance Sheet and annexed Income and Expenditure Account. We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of account audited by us and the audited Accounts of the Councils and Sections outside the United Kingdom supplied to us. In our opinion and to the best of our information and according to the explanations given us the said Accounts give the information required by the Companies Act 1948 in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institution's affairs as at 30th June, 1960 and the Income and Expenditure Account gives a true and fair view of the excess of income over expenditure for the year ended on that date.

20, Bloomsbury Square,
London, W.C.1.

10*th October*, 1960.

GIBSON, APPLEBY & CO.,
Auditors,
Chartered Accountants.

THE INSTITUTION OF PRODUCTION ENGINEERS

INCOME AND EXPENDITURE ACCOUNT for the year ended 30th JUNE, 1960

1959			1959		
		To **Establishment**		By **Subscriptions**	
1,194		Rates 1,203	41,191	Renewals and Arrears ... 50,570	
1,801		Light, Heat and Cleaning ... 1,685	572	Transfers 546	
601		Repairs and Renewals ... 640	1,134	New 2,398	
	3,596		5,464	Councils and Sections outside U.K. 5,186	
		„ **Administration**			58,700
2,943		Postage and Telephone ... 3,221		„ **Admission Fees**	
4,897		Printing and Stationery ... 6,210	784	Entrance 1,216	
408		Professional Charges and Insurance 318	1,344	Registration 1,780	
116		Banking Services — Subscriptions 116	1,659	Exemption 2,499	
250		Audit 250	98	Thesis 124	
3,368		Travel, Entertaining and Meetings (other than Sections) 3,322			5,619
			511	„ **Interest**	778
1,000		Secretary's Commonwealth Visit 81	39,537	„ **Journal**	45,711
47		Miscellaneous 97	31	„ **Sale of Proceedings**—Net ...	5
	13,029		11	„ **Miscellaneous**	10
	24,570	„ **Salaries**	581	„ **Examinations**	364
		„ **Sections**	60	„ **Conferences**	52
2,338		United Kingdom 2,343	80	„ *Annual Dinner*	—
3,393		Outside U.K. (Audit Fees £100) 4,410			
1,667		Central Services 1,665			
	7,398				
		„ **Journal**			
29,724		Printing 36,058			
6,976		Postage and Envelopes ... 8,098			
144		Reporting 103			
	36,844				
	441	„ **Institution Papers**			
	314	„ **Hazleton Memorial Library** ...			
	299	„ **Schofield Scholarship**			
	187	„ **Donations and Subscriptions** ...			
		„ **Miscellaneous**			
56		Press Cuttings 61			
200		Bank Interest and Charges ... 331			
—		Summer Meeting 549			
—		Annual Dinner 37			
141		Promotion and Publicity ... 220			
	397				
		To **Provisions**			
	1,193	Depreciation—Furniture and Fittings			
	88,268				
	4,789	„ Balance—Excess of Income over Expenditure carried down ...			
	£93,057		£93,057		

APPROPRIATION ACCOUNT

1959			1959		
560	To **Royal Charter Petition Expenses**	485	30,158	By Balance at 1st July, 1959	37,357
	„ **Building Maintenance Reserve:-**		4,789	„ Excess of Income over Expenditure brought down	11,170
1,000	Transfer 1,000		4,470	„ *Recovery of Income Tax on Covenanted Subscriptions*	—
500	Special Allocation 1,000				
		2,000			
—	„ **Provision for Schofield Scholarship 1961**	500			
37,357	„ Balance carried forward ...	45,542			
£39,417		£48,527	£39,417		£48,527

THE INSTITUTION OF PRODUCTION ENGINEERS

INVESTMENTS AT COST 30th JUNE, 1960

1959			
	United Kingdom		
	The Lord Austin Prize Fund		
	£95 8s. 5d. 3½% War Stock	100	
	£575 8s. 3d. London County 3% Consolidated Stock 1920	400	
500		—	500
	The Hutchinson Memorial Fund		
100	£95 8s. 5d. 3½% War Stock		100
	The George Bray Memorial Fund		
500	£775 0s. 9d. London County 3% Consolidated Stock 1920		500
	Life Subscriptions Fund		
	£1,854 19s. 3d. 3% Savings Bonds 1955/65	1,668	
1,122	£489 6s. 5d. 3% Savings Bonds 1965/75	388	2,056
2,222			3,156
	Outside United Kingdom		
	5% Auckland City Council Debentures		
	Maturing 1st February, 1966	250	
	Maturing 15th April, 1969	250	
500		—	500
£2,722		(Market Value £3,290)	£3,656

SUMMARY OF INCOME AND EXPENDITURE ACCOUNT for the year ended 30th June, 1960

	U.K	*Outside U.K.*		*U.K*	*Outside U.K.*
Expenditure	95,612	4,457	Income	105,718	5,521
Balance carried down	10,106	1,064			
	£105,718	£5,521		£105,718	£5,521
Special Expenditure and Allocations	2,985	—	Balance brought down	10,106	1,064
Total Excess of Income over Expenditure	7,121	1,064			
	£10,106	£1,064		£10,106	£1 064

NOTES: 1. The U.K. Expenditure of £95,612 includes the cost of supplying the Institution's Journal and other services to all members outside the United Kingdom.

2. Cash remitted to London by Councils and Sections outside the United Kingdom during the year ended 30th June, 1960, and not shown by the above figures amounted to £1,558.

ANALYSIS OF ASSETS AND LIABILITIES AT 30th June, 1960

	U.K	*Outside U.K.*		*U.K*	*Outside U.K.*
Accumulated Funds and Surplus	64,681	9,361	**Fixed Assets**		
Melbourne Prize Account — Australia	—	76	Freehold Premises	38,240	—
			Furniture, Fittings and Plant	5,741	544
			Fund Investments	3,156	500
				47,137	1,044
Current Liabilities			**Current Assets**		
Sundry Creditors and Provisions	8,989	498	Sundry Debtors, Deposits and Stocks	16,188	89
Subscriptions received in Advance	478	40	Investment — South Africa	—	3,000
			Cash at Bank and in Transit	10,823	5,842
	£74,148	£9,975		£74,148	£9,975

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---

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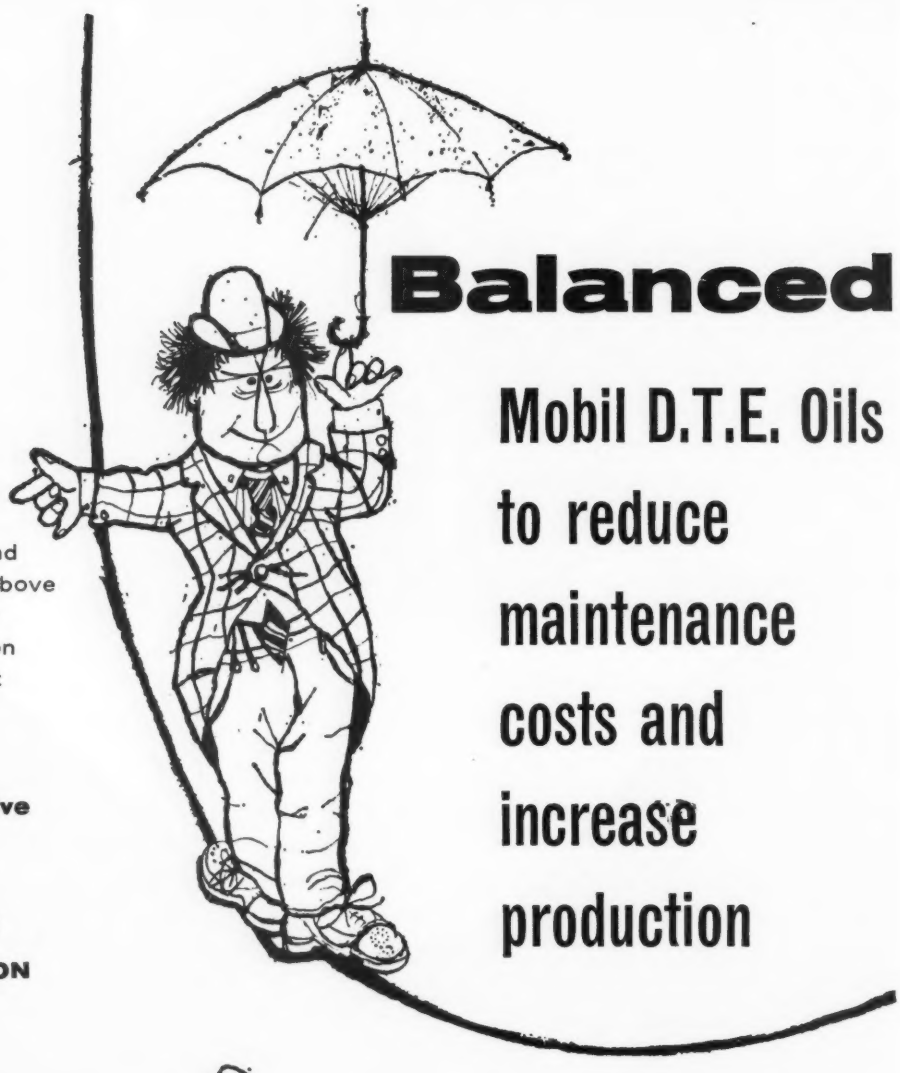

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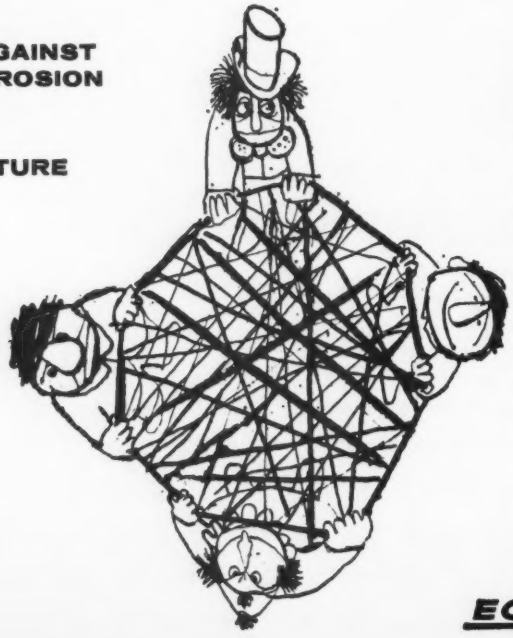

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Midlands	A. C. Turner	**South Eastern**	J. Aikman
North Midlands	J. Cox	**Southern**	J. W. Taylor
Northern	T. Young	**South Western**	A. Eustace
North Western	J. P. Speakman	**Wales**	A. E. Haynes

SECTION HONORARY SECRETARIES

AUSTRALIA

Adelaide (South Australia) ...	B. H. M. Coombes, 11 Elmo Avenue, Westbourne Park, Adelaide, Australia.
Melbourne (Victoria,Australia)	A. G. Jones, 13 Laburnum Street, Middle Brighton, Victoria, Australia.
Melbourne Graduate (Victoria Australia)	E. P. H. James, 455 Stephenson Road, Mount Waverley, Melbourne, Victoria, Australia
Sydney (New South Wales)	K. G. Slorach, 98 Church Street, Castle Hill, New South Wales, Australia.

CANADA

Canada	A. M. Hand, 18 Rintella Court, Scarborough, Ontario, Canada.

INDIA

Bombay	R. Rai, 85 Marine Drive, Bombay 2, India.
Calcutta	C. K. Haldar, Asst. Director General, Ordnance Factories, 6 Esplanade East, Calcutta, 1

NEW ZEALAND

New Zealand	A. F. Noutch, 6 Trafalgar Road, Milford, Auckland, New Zealand.

SOUTH AFRICA

South Africa	A. Aitken, 209-211 Pharmacy House, 80 Jorissen Street, Johannesburg, P.O. Box 10837 South Africa.

UNITED KINGDOM

Birmingham	W. Silberbach, 45 Bagnell Road, Kings Heath, Birmingham, 14
Cardiff	A. E. Haynes, c/o A. B. Metal Products Ltd., Abercynon, Glamorgan.
Cornwall	F. G. Hawke, 3 Bellevue Terrace, East Hill, Tuckingmill, Camborne, Cornwall
Coventry	A. S. Hopkins, 39 Oaks Road, Kenilworth, Warwicks.
Derby	W. F. Radford, 15 Sherwood Avenue, Chaddesden, Derby.
Doncaster	G. R. Wimpenny, 16 Tickhill Square, Denaby Main, Doncaster.
Dundee	A. J. Fraser, 51 Fintry Drive, Dundee.
Edinburgh	D. A. Bowman, The Scottish Council (Dev. and Ind.), 1 Castle Street, Edinburgh.
Glasgow	W. H. Marley, North British Locomotive Co. Ltd., Diesel Engine Division, Atlas Works, Springburn, Glasgow, N.1.
Gloucester	A. M. Blew, Field Place, Badgeworth Road, Cheltenham, Gloucestershire.
Halifax & Huddersfield ...	D. B. Verity, Kendoon, 168 Roils Head Road, Norton Tower, Halifax, Yorks.
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Leicester & District	J. A. Stovin, 14 Queens Drive, Leicester Forest East, Leicester.
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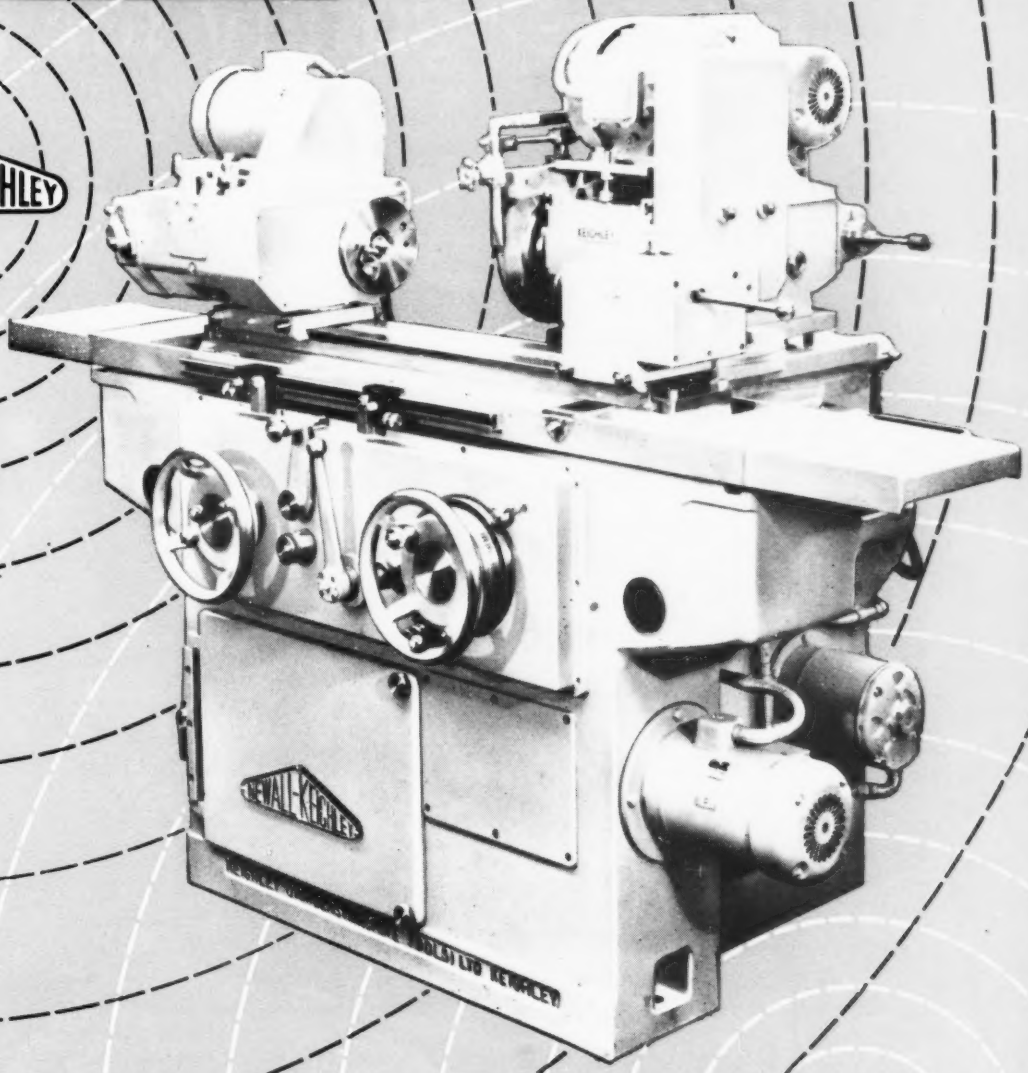

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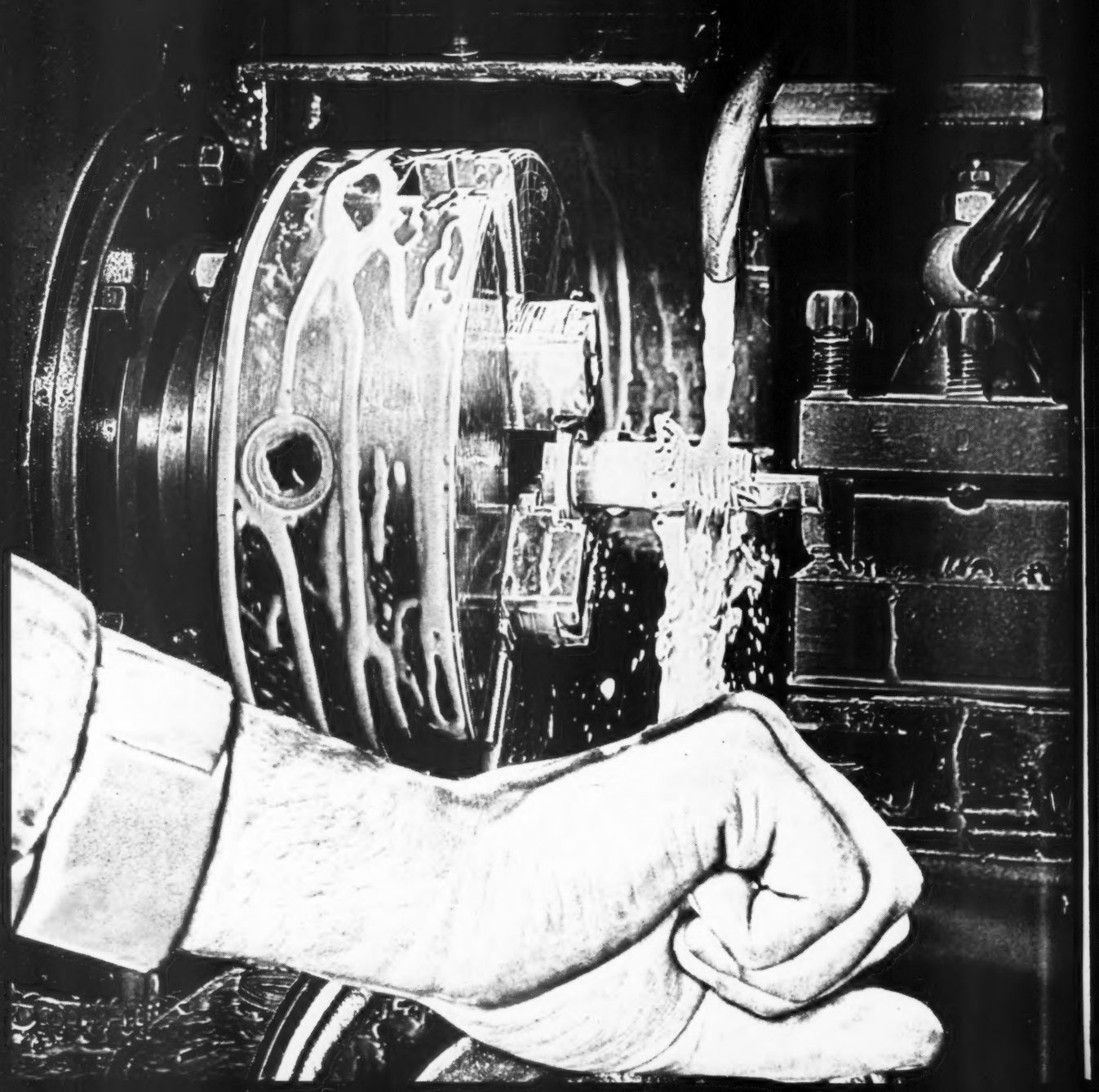
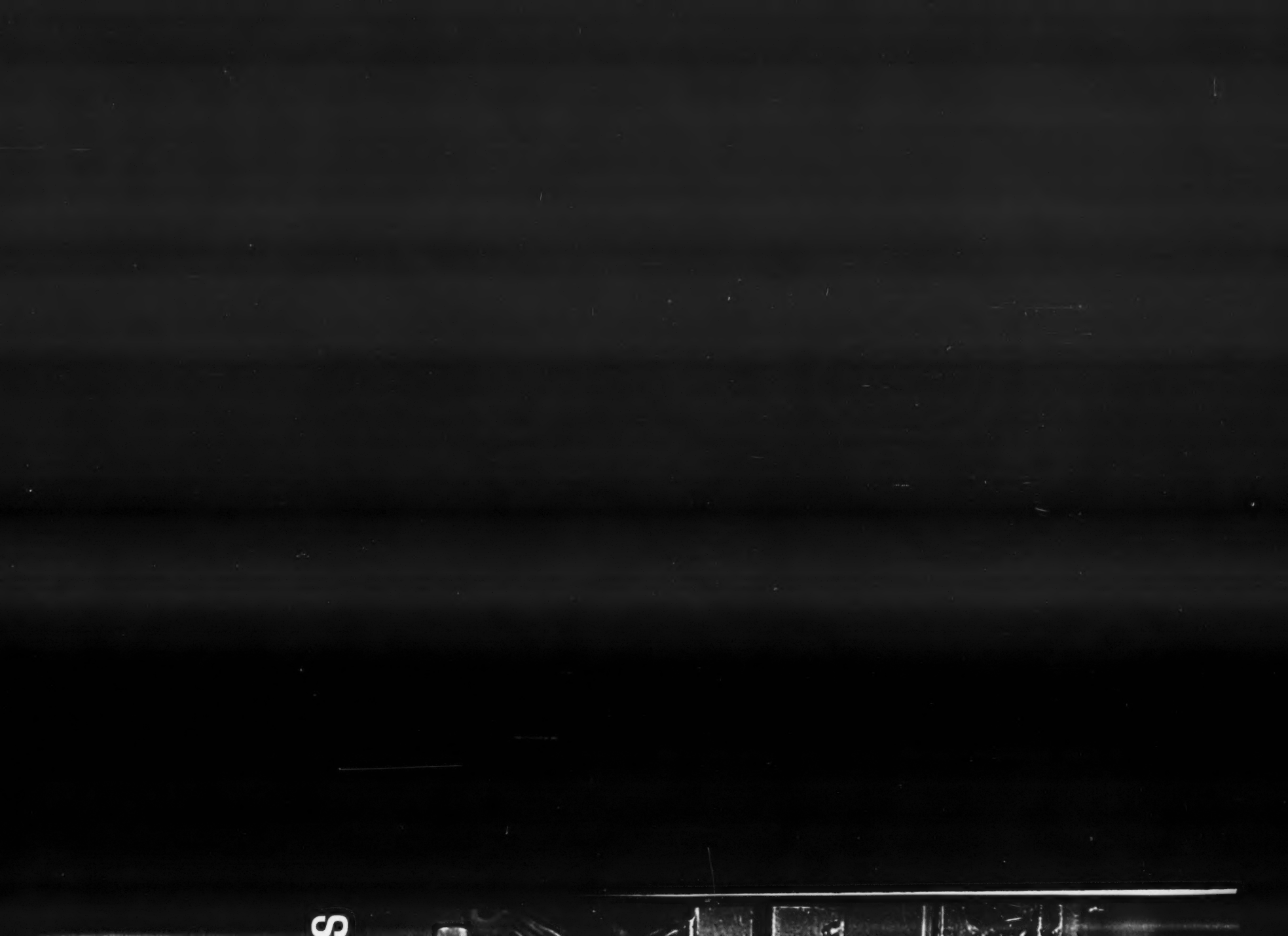




With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

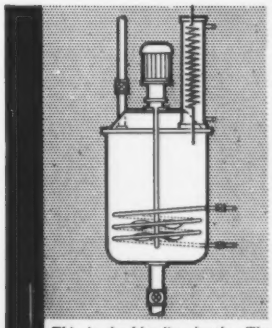
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

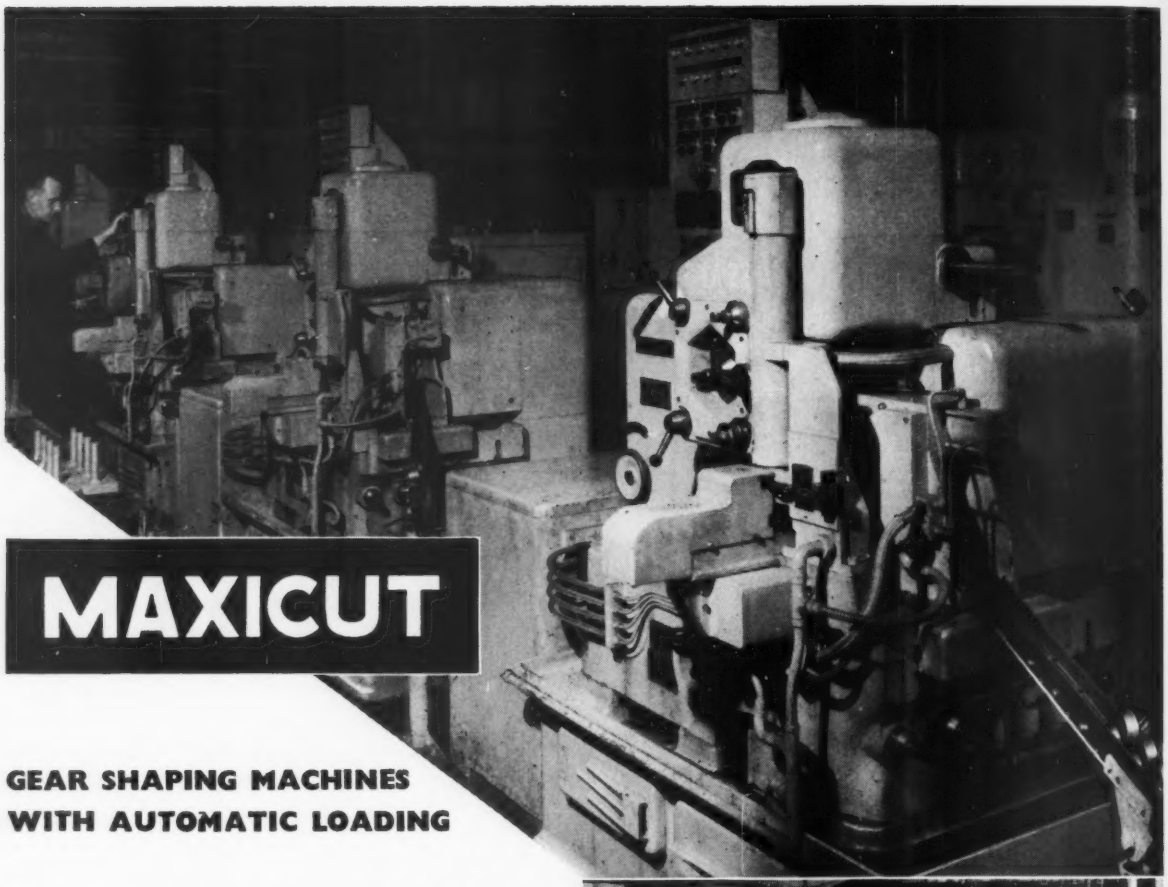
This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication



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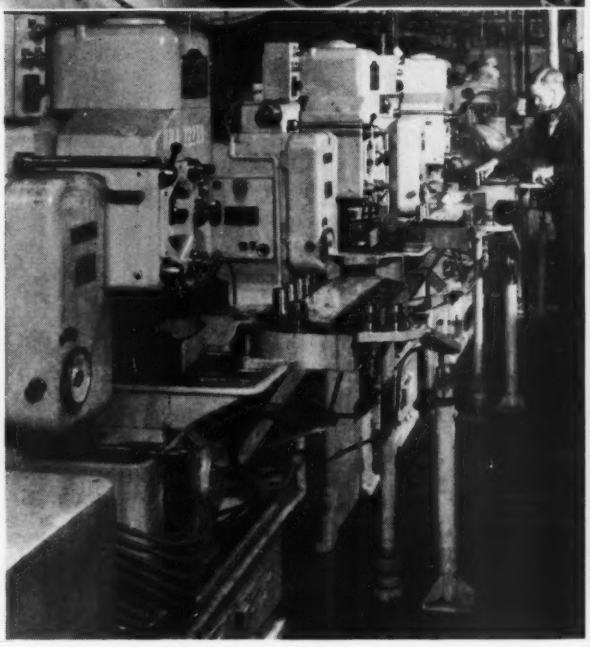
GEAR SHAPING MACHINES
WITH AUTOMATIC LOADING

for mass production of automobile gears



These illustrations show two lines of Drummond No. 2A Maxicut Gear Shapers at the Austin Motor Co. Ltd., Birmingham. Machines in the top view are equipped with magazine loading and in the bottom illustration swinging arm type loaders are fitted.

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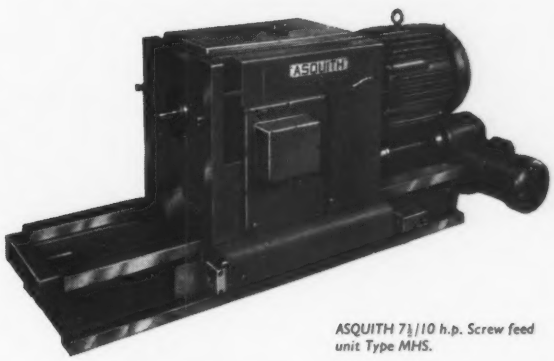
fully engineered for high-output production



ASQUITH 7½/10 h.p. Screw feed unit Type MHS.

The example illustrated is a five station, rotary table machine for drilling, reaming and milling operations on automobile spring hangers. A vertically mounted 7½ h.p. unit is arranged with the milling attachment and a 2 h.p. unit with multi-head and bush plate is also mounted on a vertical column. Another 2 h.p. screw unit operates horizontally. The 3 ft. dia. hand indexed table incorporates an air lift feature to reduce operation fatigue and clamping is automatic. The table is controlled by the foot valve at the base.

If you manufacture components in large quantities which require several machining operations, it will pay to investigate the possibility of producing them on an Asquith Unit Type Machine. Units from ½ h.p. upwards can be applied for multi-way, rotary transfer and in-line transfer operation.

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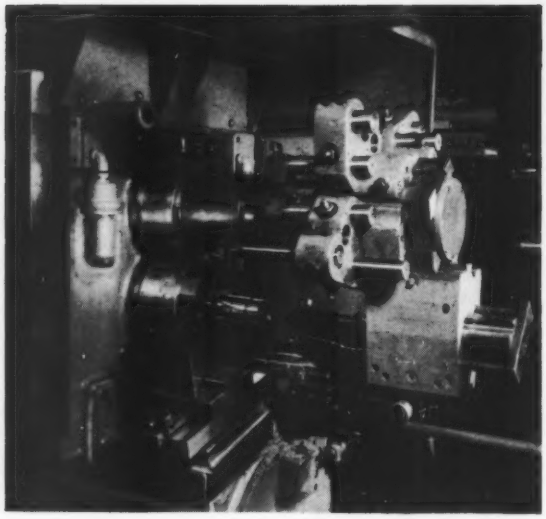

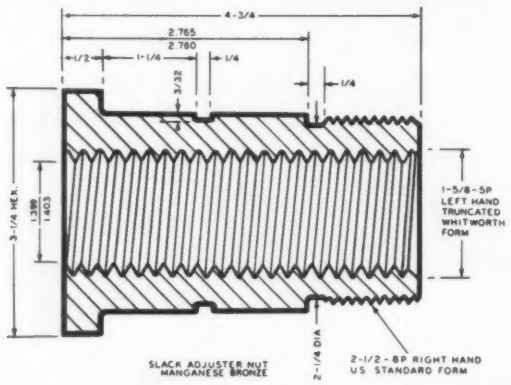

Ease and Speed of Setup, Fast Automatic Operation and Extreme Precision — these are the highlights of the Warner Swasey Asquith 2AC Single Spindle Chucking Automatic. With "No Cams to Change" it has the advantage of automatic operation without the usual time consuming setup procedure. The pentagonal control drum equipped with adjustable trips selects, feeds, speeds and length of cutting stroke. Permanent cams are used for the turret and cross slides and these two mechanisms eliminate all cam changing.

On the left is a typical production example — a manganese bronze adjuster nut, completed, including both threads, in one operation on the 2AC.

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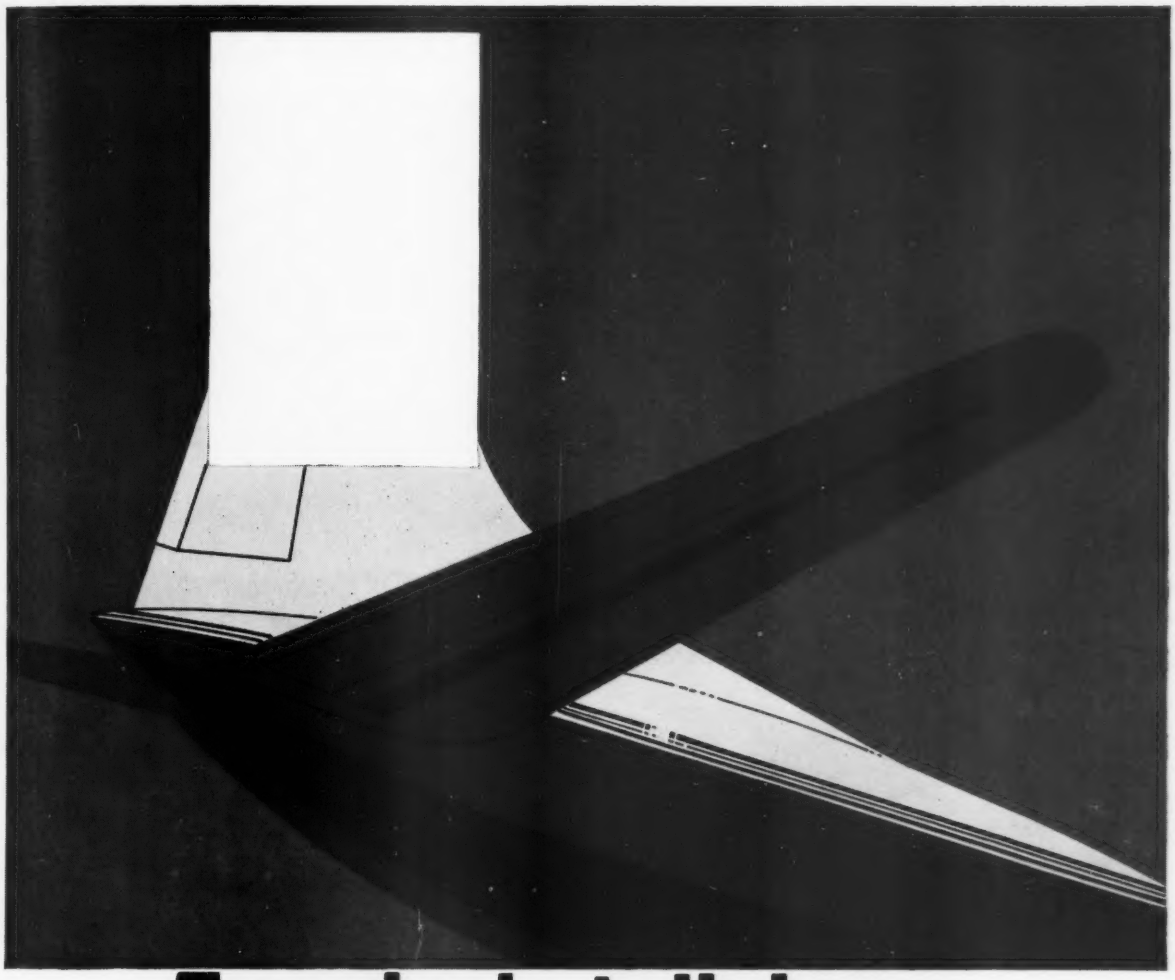
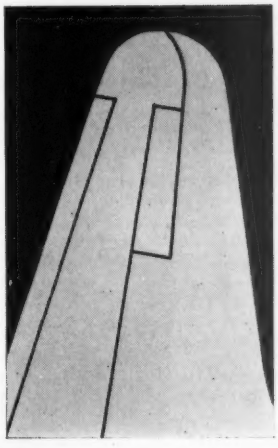


Tuesday's tailplane



There is no doubt that the tailplane will be there on Tuesday – or that every other part and sub-assembly will be available on the scheduled date.
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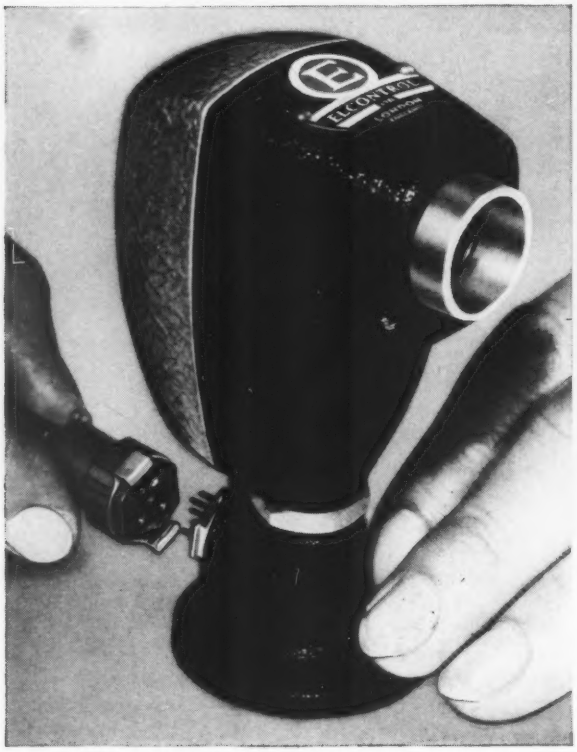

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These ELCONTROL photorelays, viewing heads and scanning units have been designed for use with modern handling, packaging and processing machines of many types.

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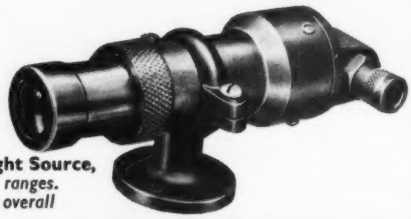
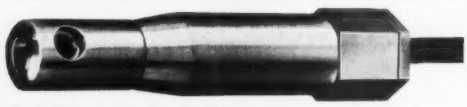


LH11 **Light Source,** *for longer ranges. 4⅛″ x 1⅝″ overall*



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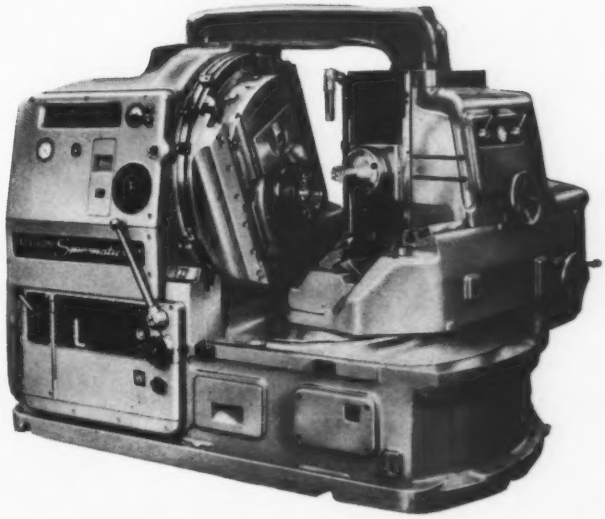

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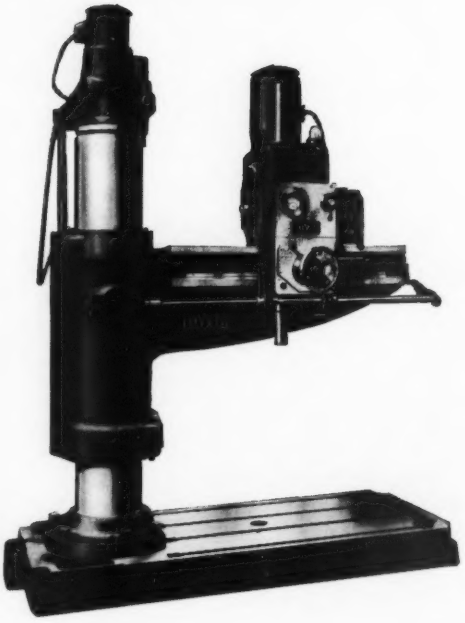

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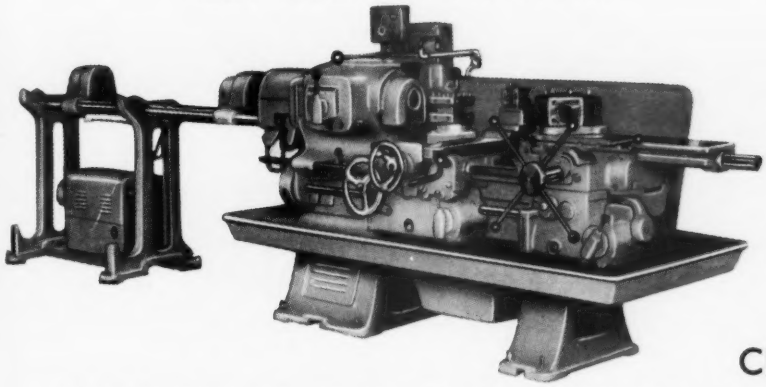
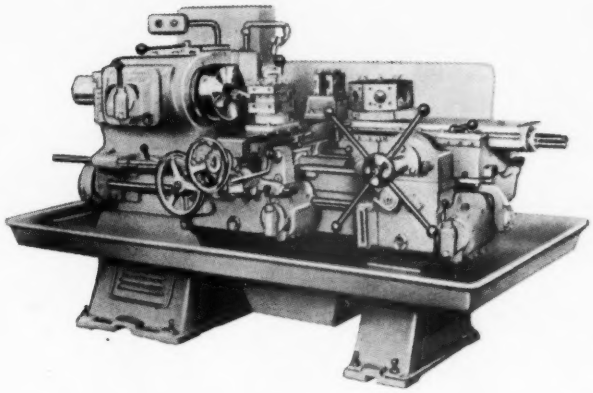
RAM TYPE FOR BAR WORK



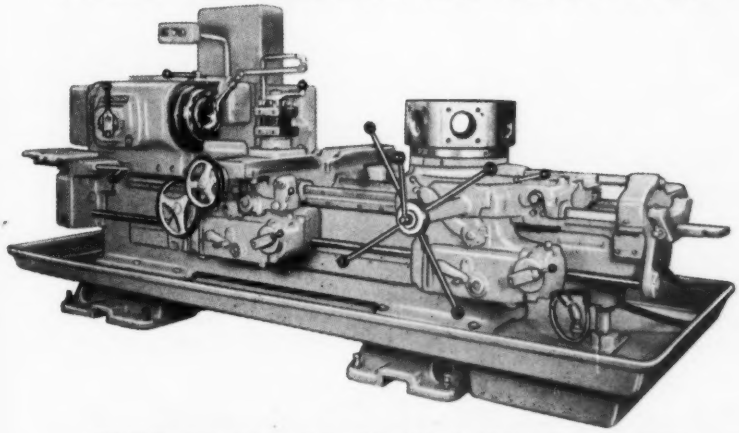
AVAILABLE IN 5 SIZES FOR BARS $\frac{3}{16}$" TO $4\frac{1}{2}$" DIA.

RAM TYPE FOR CHUCK WORK



AVAILABLE IN 5 SIZES WITH 10" OR 12" CHUCKS

SADDLE TYPE FOR BAR AND CHUCK WORK



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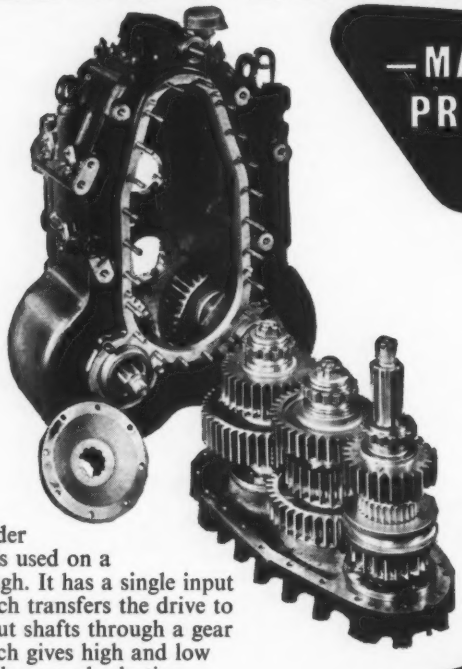
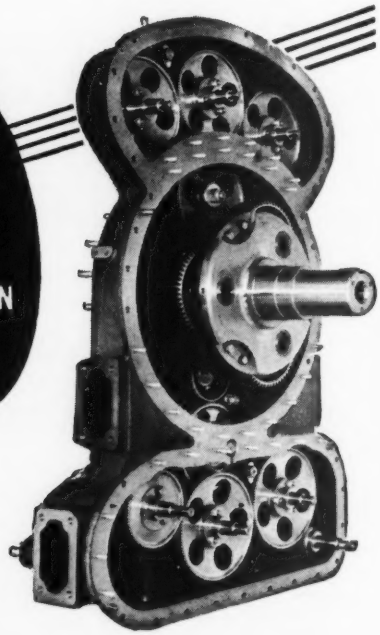
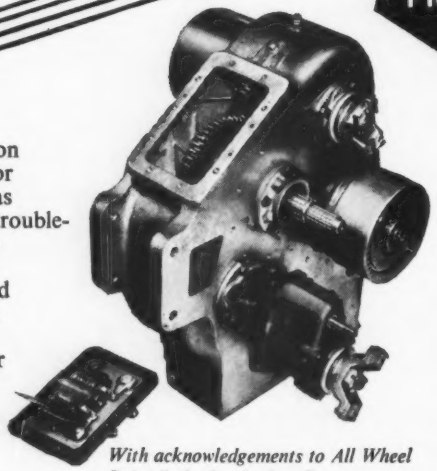


This divider gearbox is used on a snowplough. It has a single input shaft which transfers the drive to two output shafts through a gear train which gives high and low ratios with manual selection.

ACCURACY AND QUALITY ON A PRODUCTION BASIS



For use on an industrial gas turbine engine, this epicyclic gearbox reduces from 26,000 r.p.m. to an output speed of 3,000 r.p.m. in one step. There are nine auxiliary drives and a starter drive.



Used in 3 versions on "Michigan" Tractor Shovels, this box has proved completely trouble-free under the most arduous conditions. It has 4 forward and 4 reverse gears with manual high-low range selection. 2 or 4-wheel drive.

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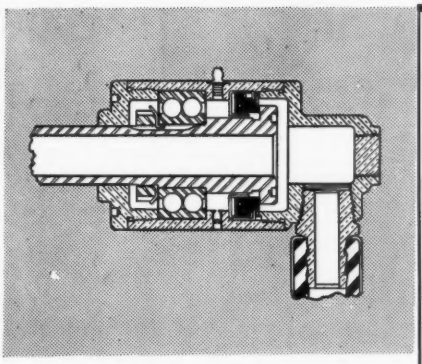
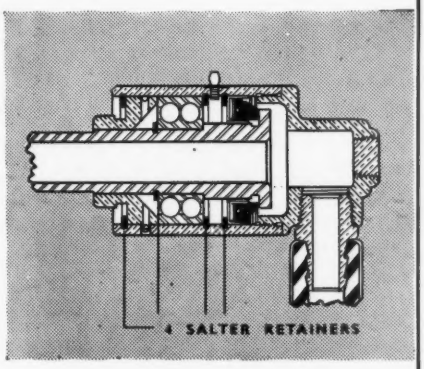


THE OLD WAY Air, water, steam union involved drilling, threading and milling operations. Maintenance was difficult.



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eliminated bearing lock nut and washer	7¾
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locate cap on arbor, and chase threads	1/-
drill spanner wrench holes	4¼
cut thread on rotor for lock nut	3¾
mill slot in thread for tang on lock washer	7½
drill spanner wrench holes in rotor	4¼
ASSEMBLY OPERATIONS ELIMINATED	
install lock washer, tighten lock nut, bend lug	8½
assemble cap into housing	4
TOTAL SAVING WITH SALTER RETAINERS	8/6½

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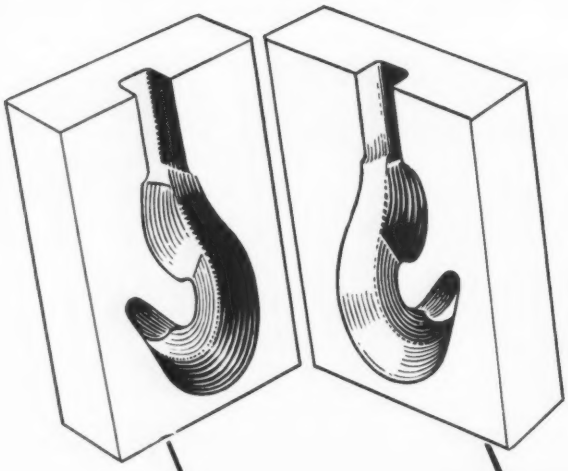
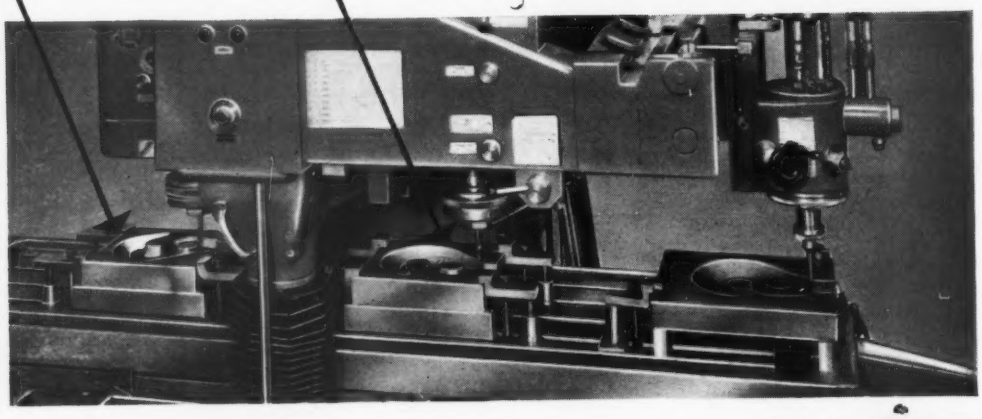


Both halves at once



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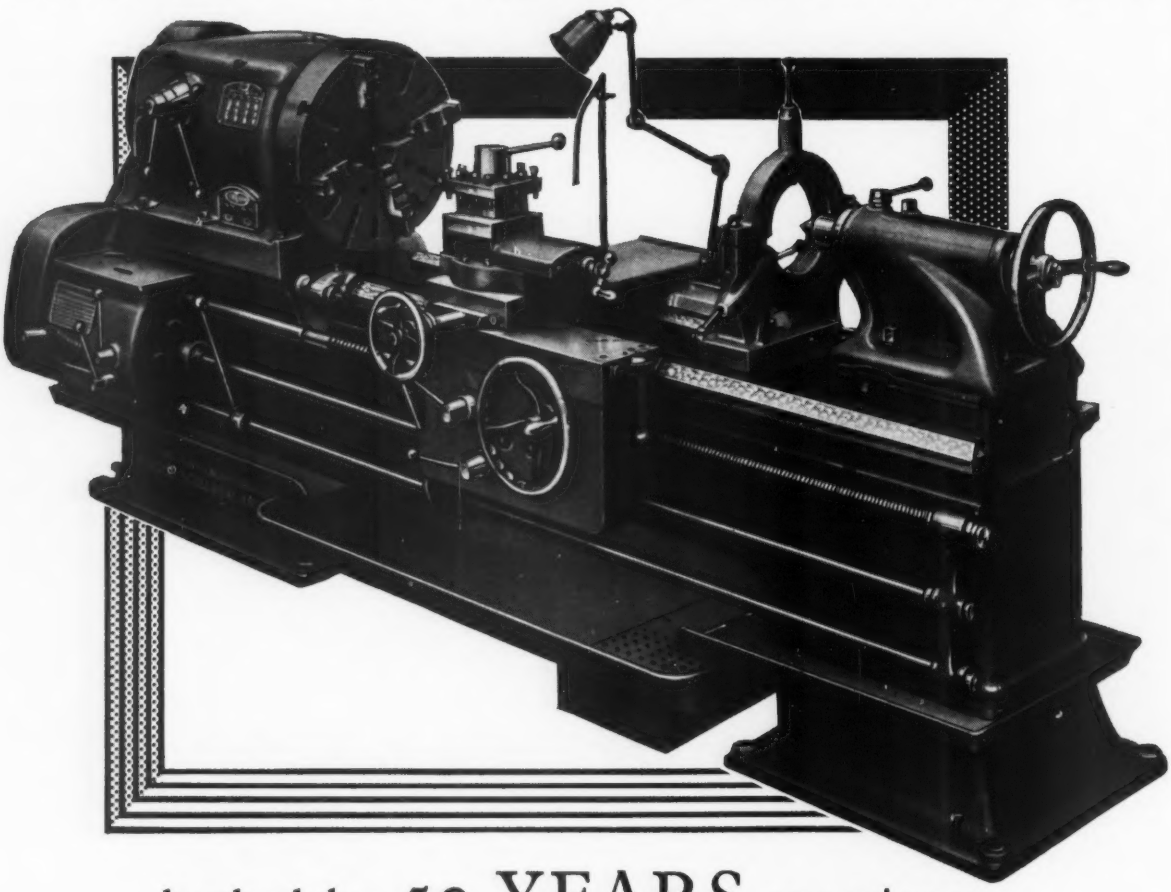

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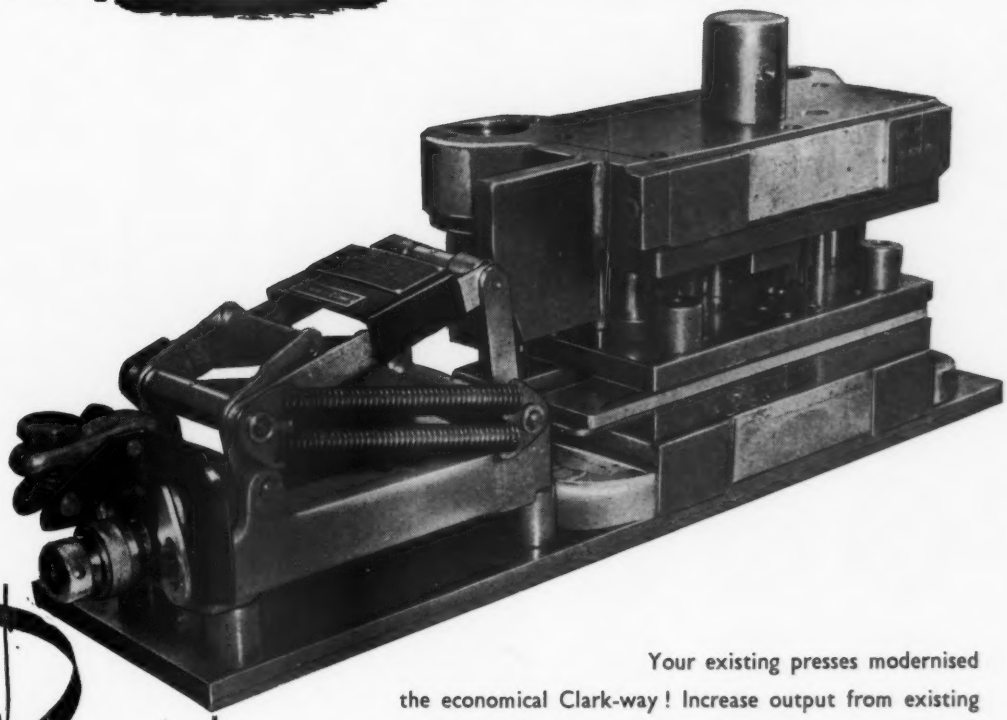

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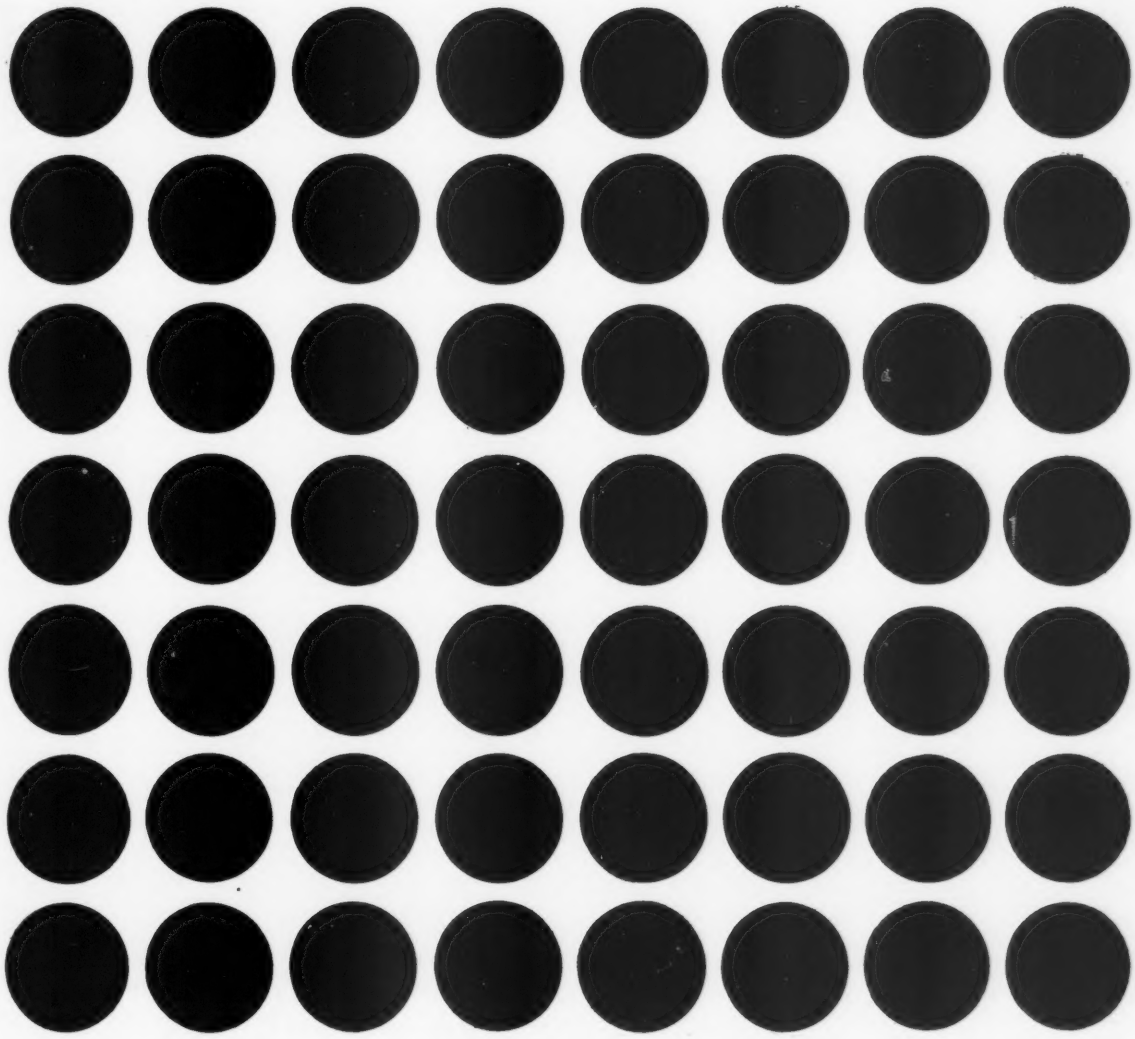

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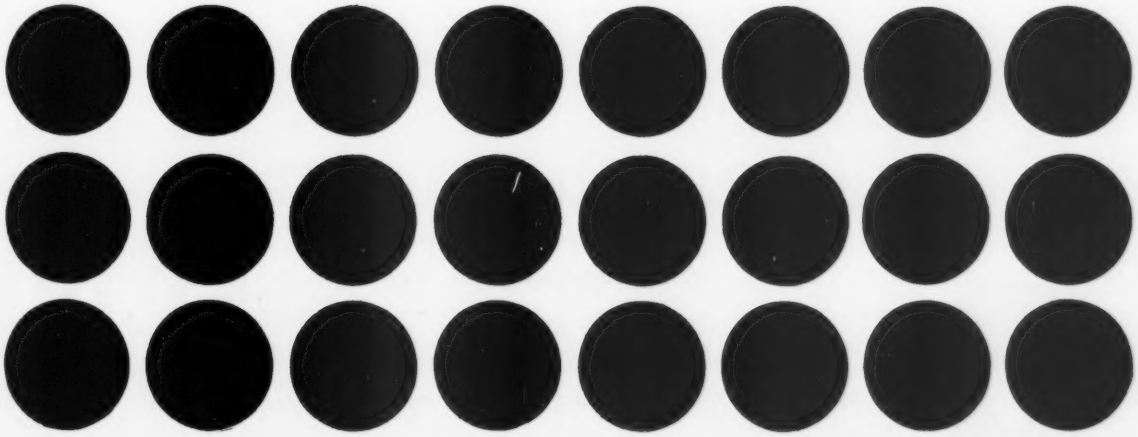

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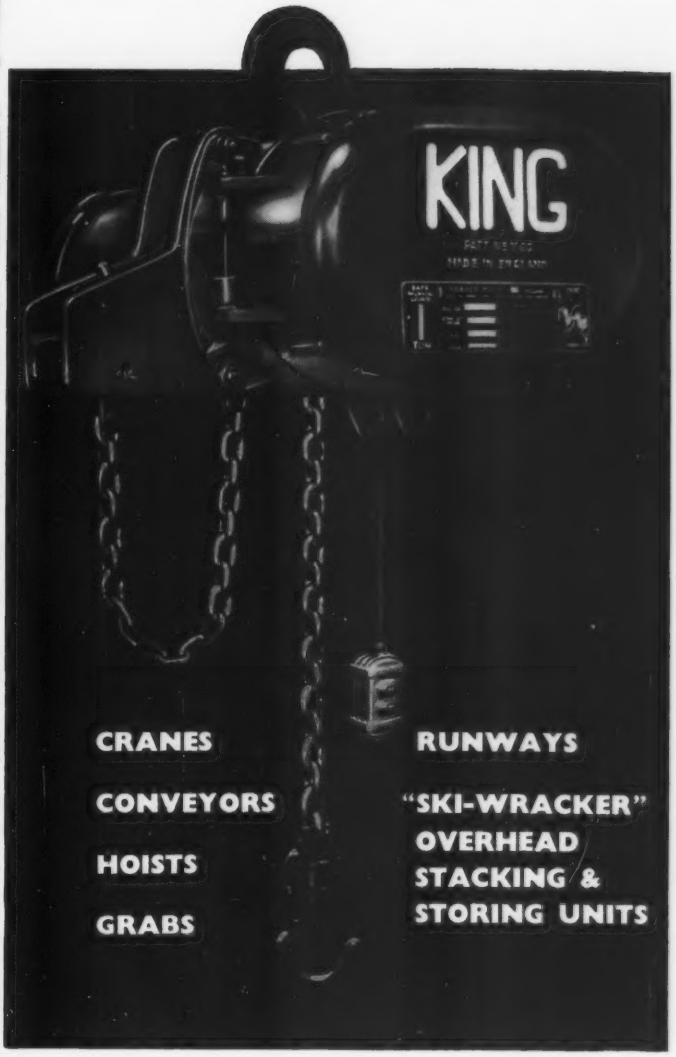

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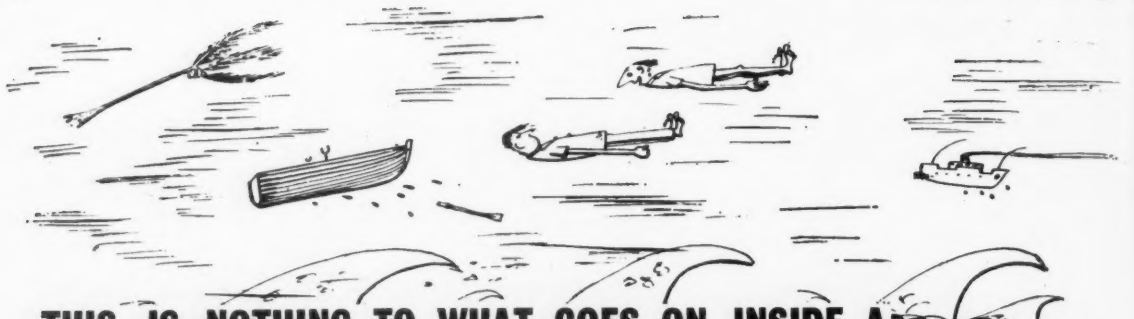

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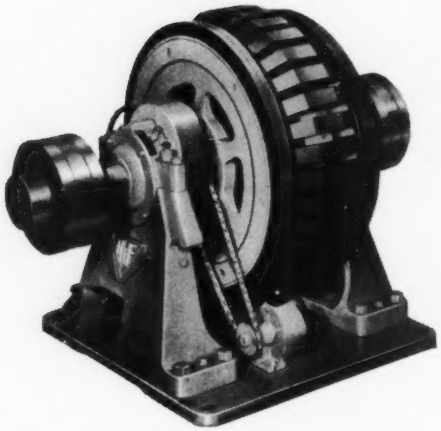

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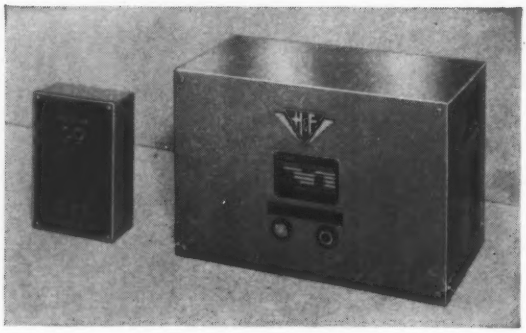

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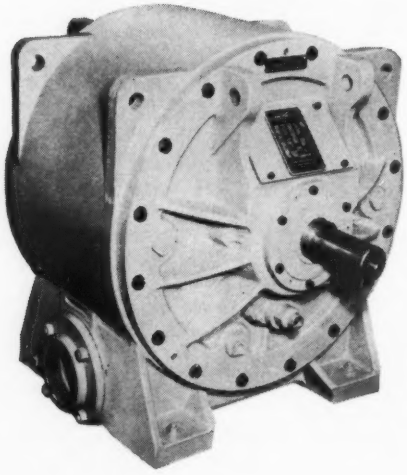

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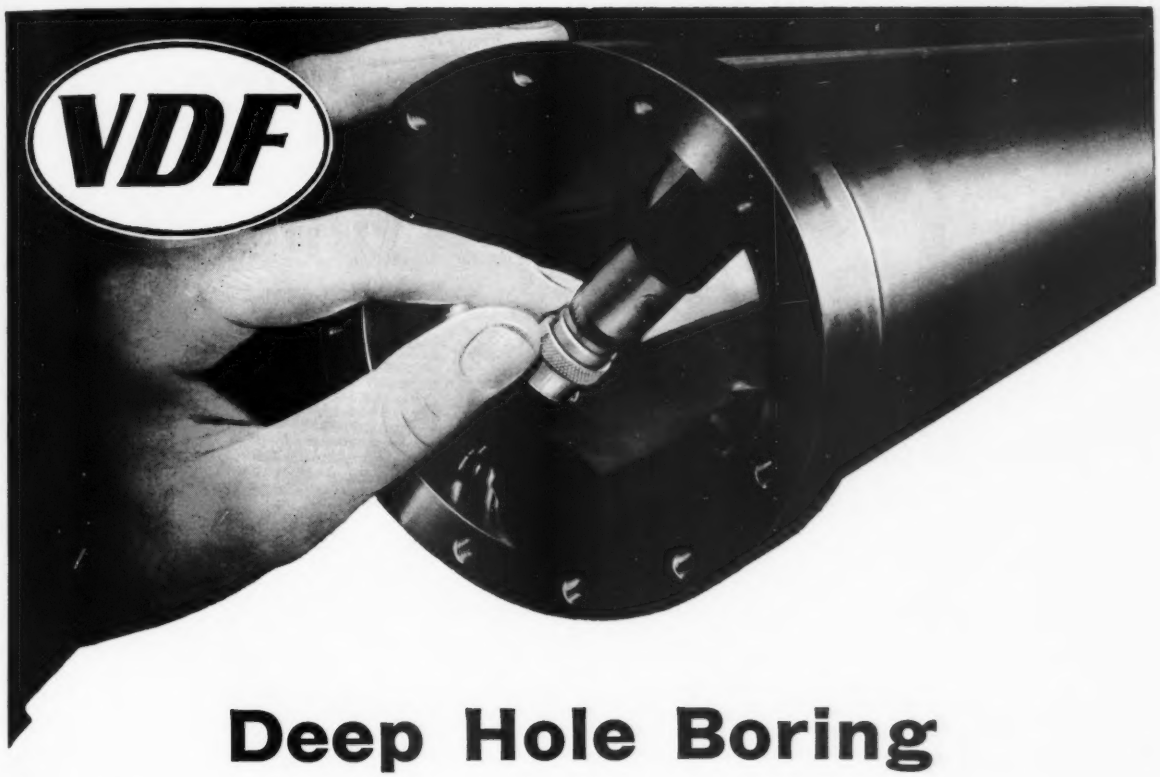
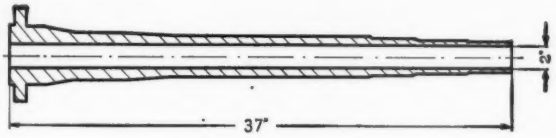
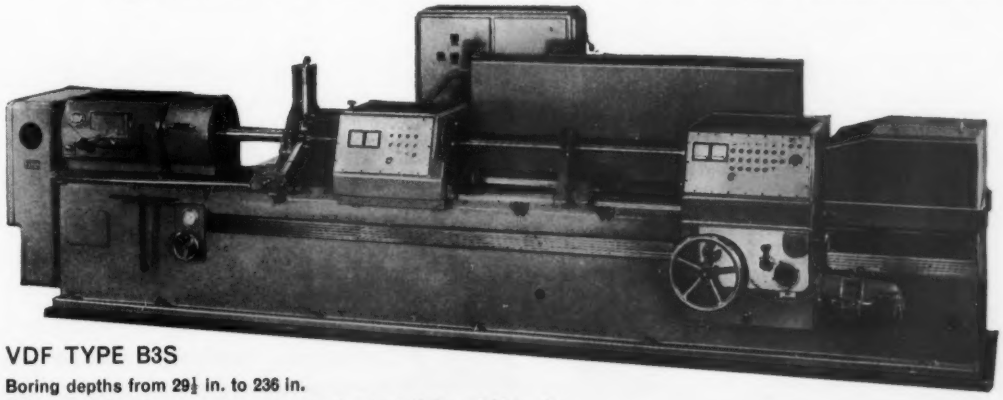


Deep Hole Boring



- Spindle Speed: 710 R.P.M.
- Feed Rate: .0063 in./rev.
- Material: EN 9.
- Floor to Floor Time: 10.5 mins.

The work spindle illustrated is machined on a V.D.F. Deep Hole Boring Machine using the solid boring method and central chip disposal. The maximum axial deviation is .0039 in. over the length of 37 in., with a surface finish of 5-10μ.



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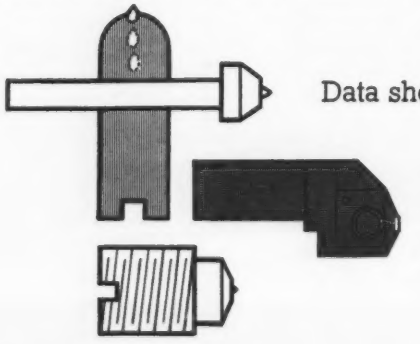

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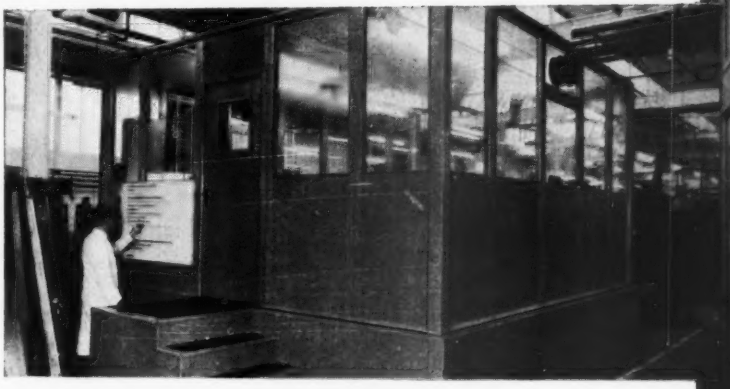

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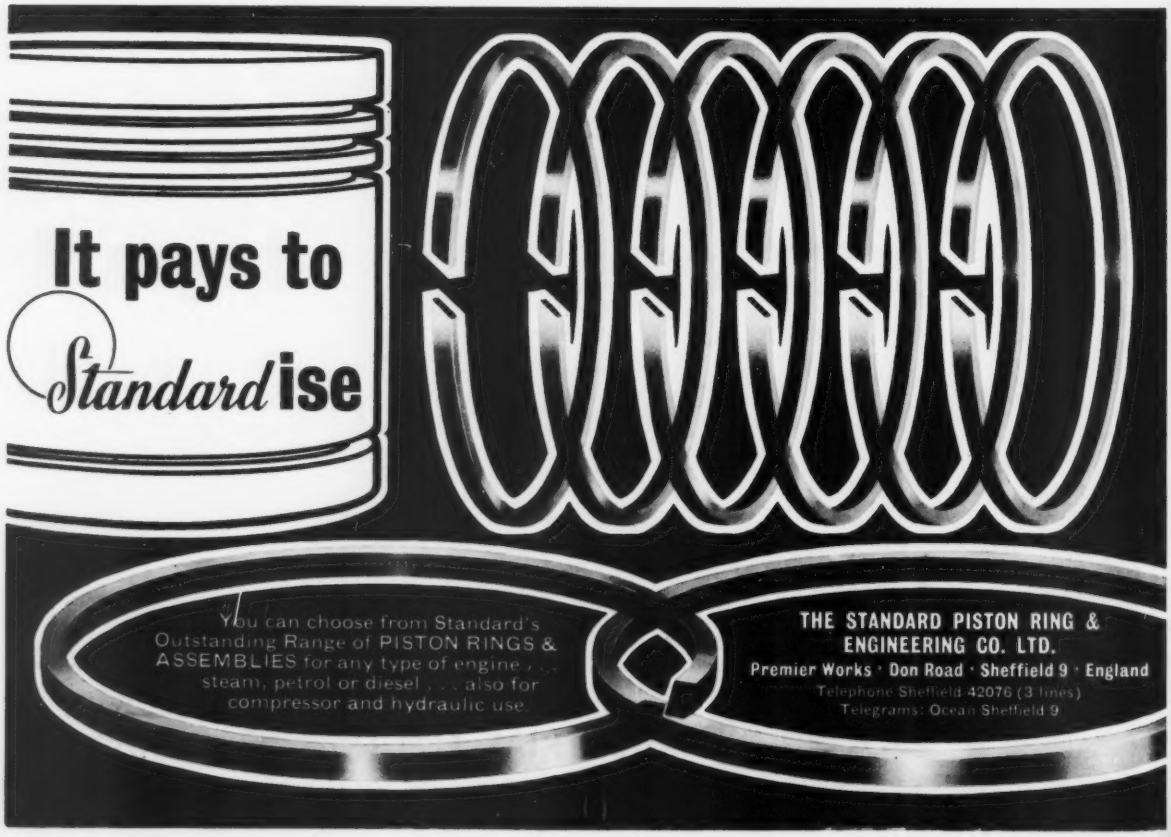
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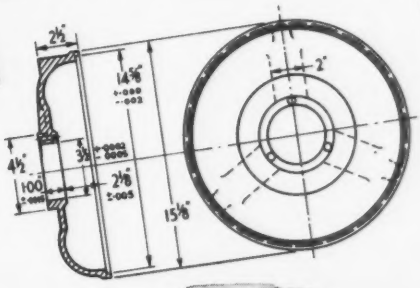

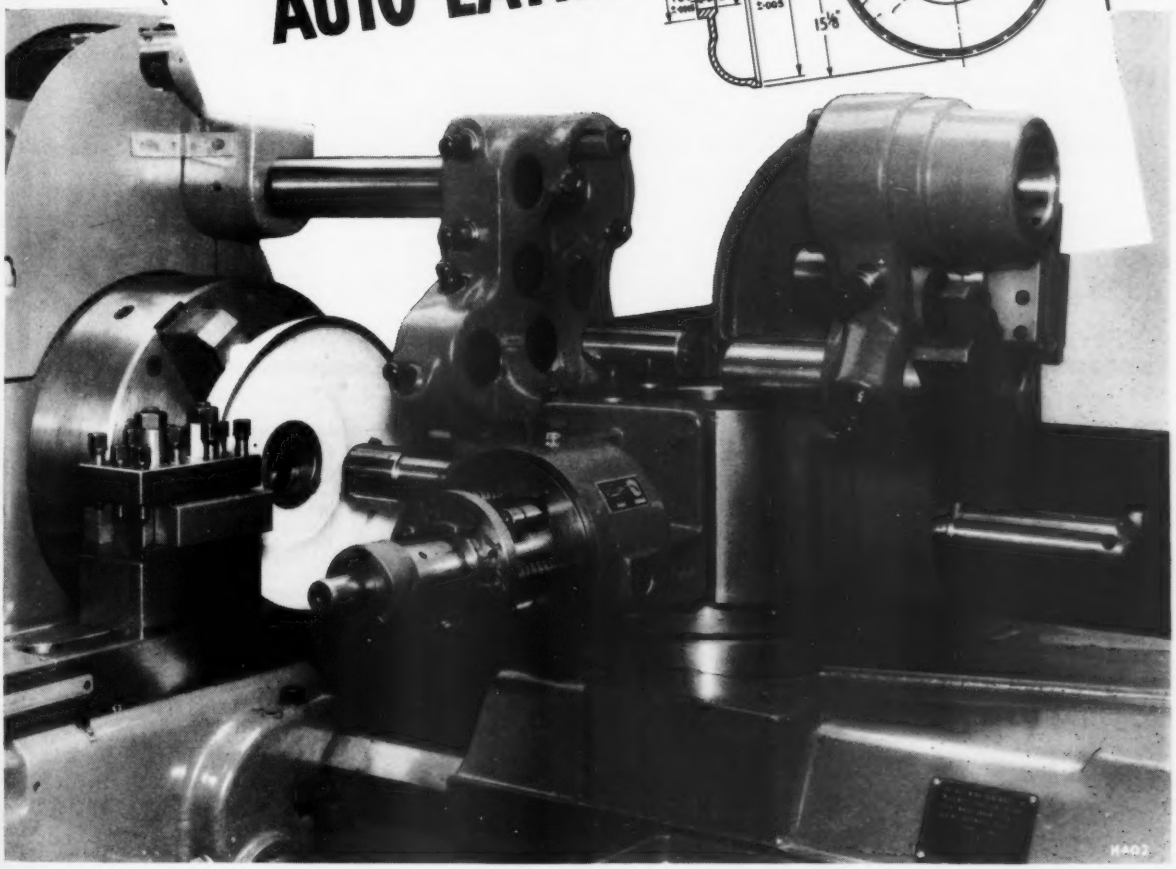

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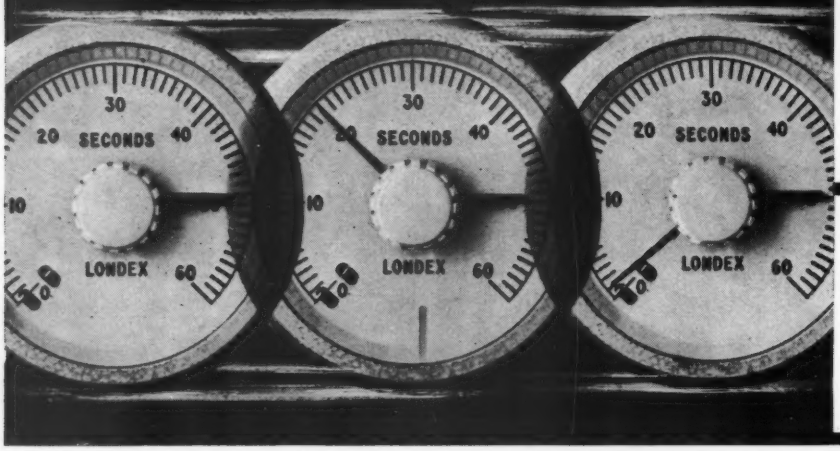
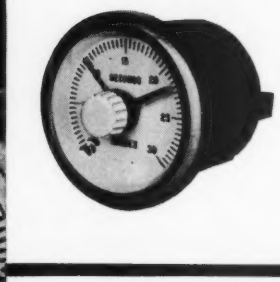
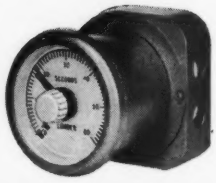
LONDEX **NEW process timer type IMP**







This timer offers a wide variety of contact arrangements without internal rewiring. It is self-resetting, can be started by a remote switch and is of medium price.

The IMP timer is available in two forms, flush mounting and wall mounting. The range includes timers to cover full scale times from 30 secs. with ½ sec. settings, up to 24 hours with 20 min. settings—**some of these available from stock.**

The timer is driven by a small but powerful self-starting synchronous motor working on 200/250v, A.C. 50 cycle supply. Contacts are rated at amps 250v. A.C.

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More and more Engineering firms are using Articulated Arm Routers

Some users of Wadkin Heavy Duty Articulated Arm Routers, Type LC

Wadkin Heavy Duty Articulated Arm Router, LC face-milling gearbox end covers. Photo by courtesy of Ruston & Hornsby Ltd., Grantham.

– *the fastest method of milling light alloys!*

Wadkin Articulated Arm Routers are not only doing jobs that would normally be done on far more costly machines but are doing them both faster and better. With cutting speeds up to 18,000 r.p.m., low tooth loading of the cutter, and only light clamping of the component, face-milling operations are machined up to 10 times faster than by any other method. Three models are available: heavy duty type L.C. with either 6′ 0″ or 8′ 0″ reach, and the recently introduced medium capacity machine, type L.C.6. Full details are given in Leaflet No. 945.

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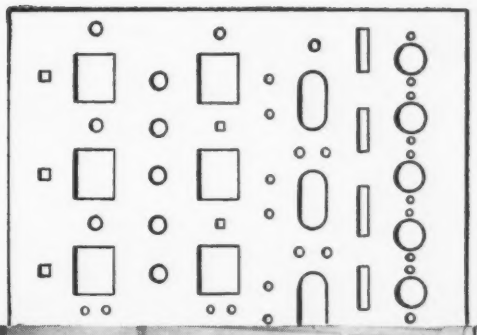

WALES

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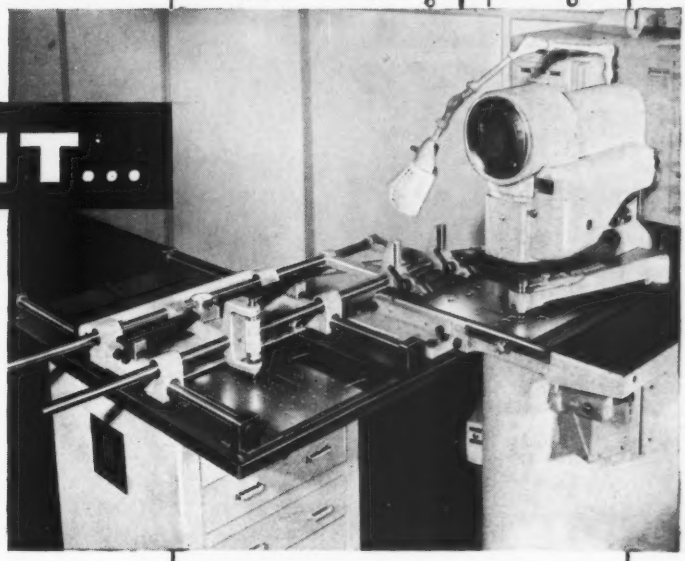

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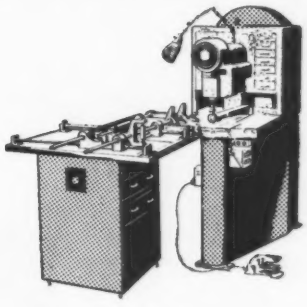
STROKES PER MINUTE — 165 for single punching or nibbling
THROAT DEPTH OF PRESS — 15"
TABLE WORKING SURFACE — 30" wide x 20" deep.



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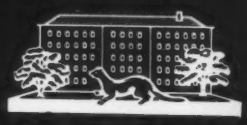

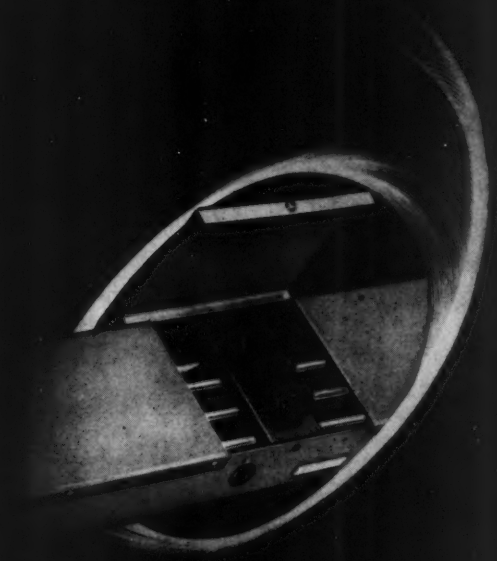

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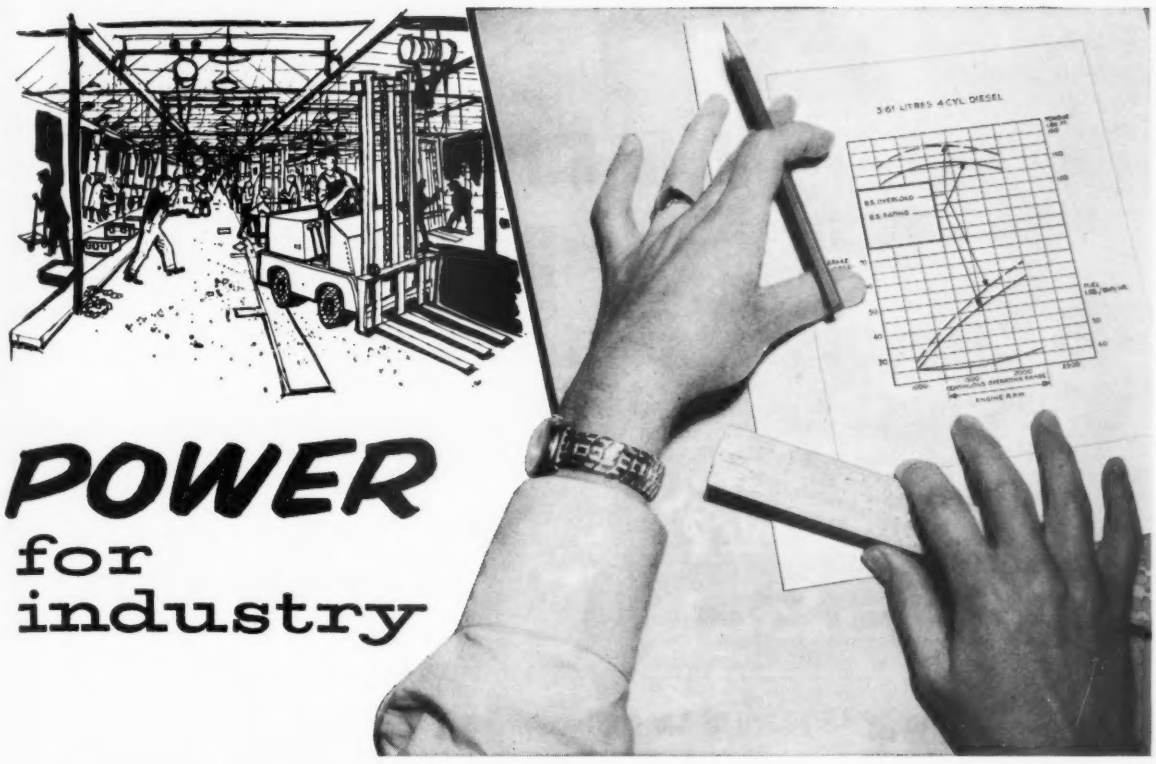

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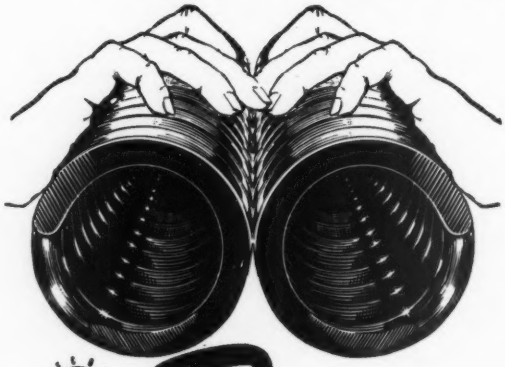

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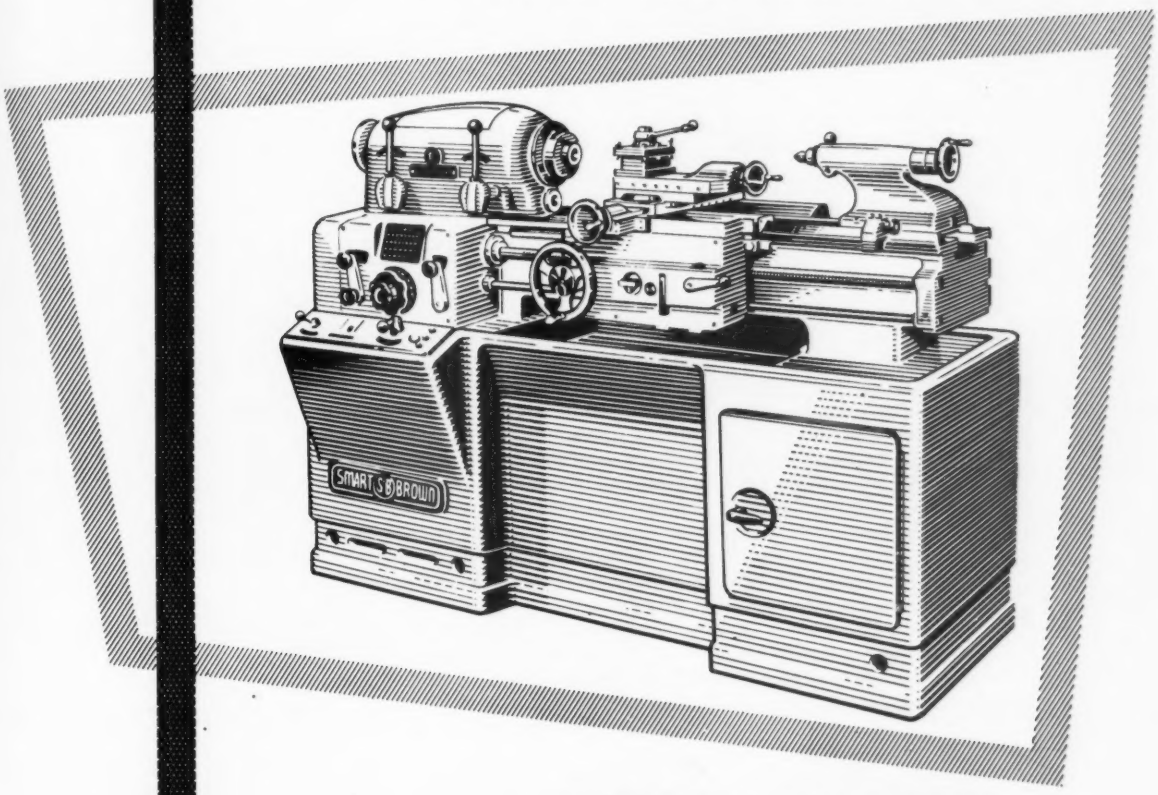

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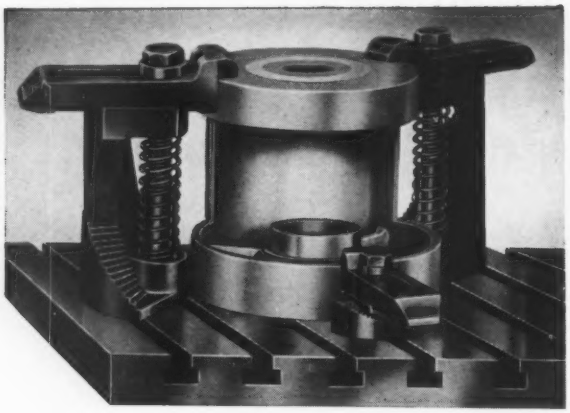

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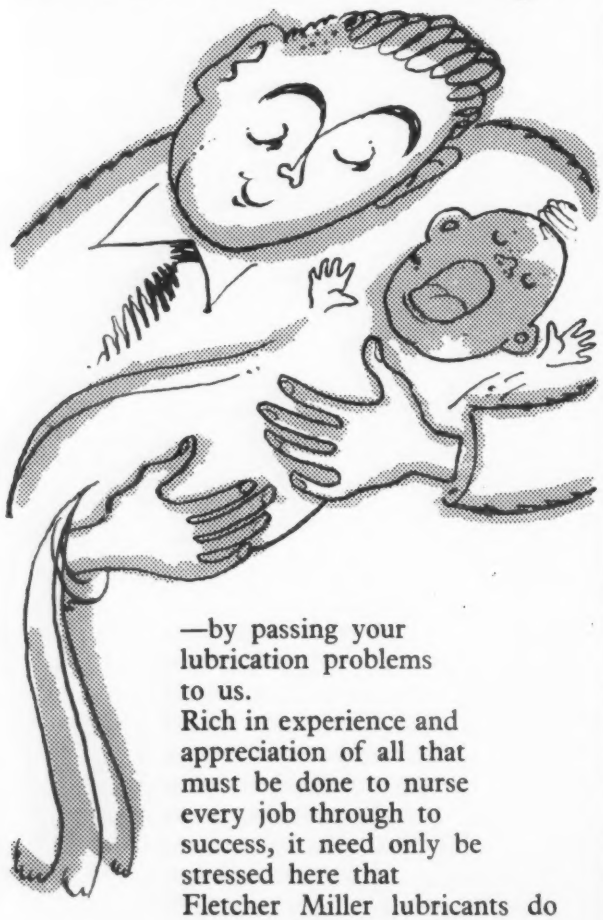

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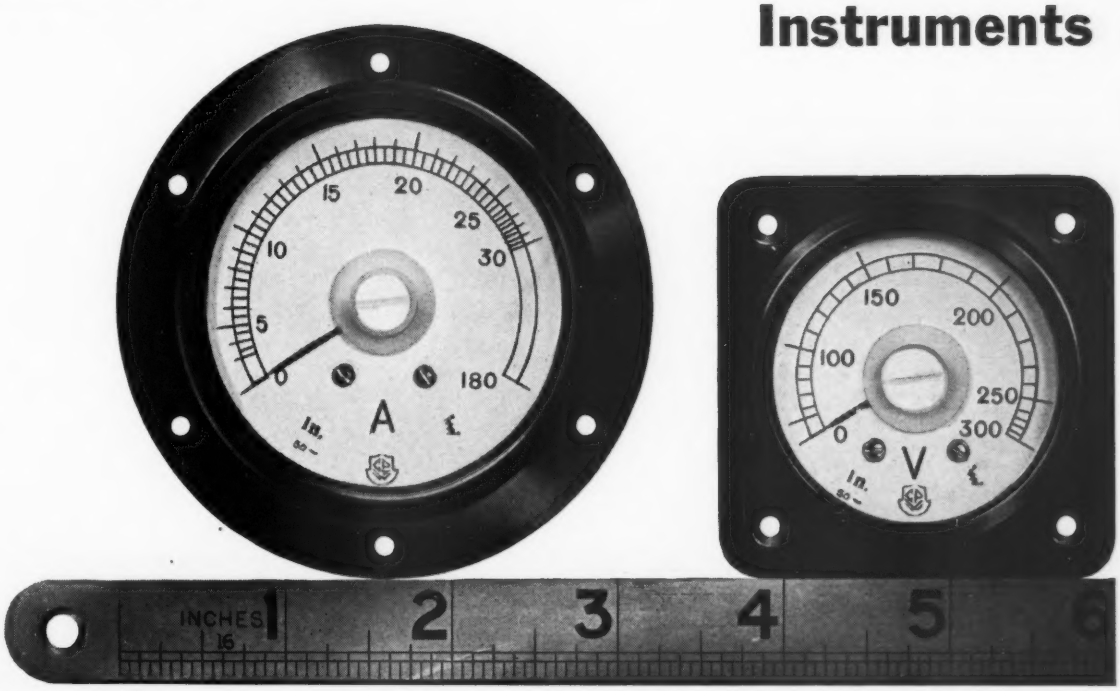

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INDEX TO ADVERTISEMENTS

Please note that all advertisement pages are prefixed with the letter "A"

	Page
A.E.I.-Birlec, Ltd.	—
Adcock & Shipley, Ltd.	A34
Adrema, Ltd.	A59
Aircraft-Marine Products (Great Britain), Ltd.	—
Airmec, Ltd.	—
Allen, Edgar, & Co. Ltd.	A12
Allspeeds, Ltd.	A37
Archdale, James, & Co. Ltd.	A16
Asquith, Williams, Ltd.	A57
Associated Electrical Industries, Ltd.	A93
Atlas Copco (Great Britain), Ltd.	—
Automotive Engineering, Ltd.	A70
B.S.A. Tools, Ltd.	A7
Barber & Colman, Ltd.	—
Baty, J. E., & Co. Ltd.	—
Baume & Co. Ltd.	—
Benton & Stone, Ltd.	A41, A92
Birmingham Aluminium Casting (1903) Co. Ltd.	—
Birmingham Tool & Gauge Co. Ltd.	A14
Bishop, Eaves, & Sons, Ltd.	—
Bliss, E. W. (England), Ltd.	—
Block & Anderson, Ltd.	—
Brauer, F., Ltd.	A44
British Aero Components, Ltd.	—
British Industrial Eng. Co. (Staffs.), Ltd.	A19
British MonoRail, Ltd.	—
British Oxygen Co.	A35
British Steel Founder's Association	—
British Timken; Division of The Timken Roller Bearing Co.	—
Brockhouse, J., & Co. Ltd.	—
Broom & Wade, Ltd.	A87
Brown, David, Corpn. (Sales), Ltd., The	A75
Buck & Hickman, Ltd.	A63
Bullows, Alfred, & Sons, Ltd.	A74
Burton Griffiths & Co. Ltd.	A7
Butler Machine Tool Co. Ltd., The	—
Calor Gas (Distributing) Co. Ltd.	—
Canning, W., & Co. Ltd.	A2
Carborundum Co. Ltd., The	A45
Carrier Engineering Co. Ltd.	—
Centec Machine Tools, Ltd.	A4
Centrax Ltd.	A64
Churchill, Charles, & Co. Ltd.	A1
Churchill Machine Tool Co. Ltd.	A28
Ciba (A.R.L.), Ltd.	A71
Cincinnati Milling Machines, Ltd.	A8, A9
Clark's Press Equipment, Ltd.	A69
Concentric Manufacturing Co. Ltd.	A30
Cooper & Co. (B'ham), Ltd.	—
Coventry Climax Engines, Ltd.	*Outside Back Cover*
Crawford Collets, Ltd.	A40
Crompton Parkinson, Ltd. (Instruments)	A95
Crompton Parkinson (Stud Welding), Ltd.	—
Crosland, William, Ltd.	A86
Crowthorn Engineering Co. Ltd.	A68
Davis, Stuart, Ltd.	A29
Dawson Bros., Ltd.	—
Dean Smith & Grace, Ltd.	A10
Dee Oil Co. Ltd.	—
Denham's Engineering Co. Ltd.	—
Dowding & Doll, Ltd.	A66
Drummond-Asquith, Ltd.	A58
Drummond Bros., Ltd.	A56
E.N.V. Engineering Co. Ltd.	—
Edwards, F. J., Ltd.	A80
Efco Furnaces Ltd.	—
Elcontrol, Ltd.	A60
Electrical Development Association	—
Electric Resistance Furnace Co. Ltd.	—
Elliott, B. (Machinery), Ltd.	A46
English Electric Co. Ltd., The	—
English Electric Aviation, Ltd.	—
English Numbering Machines, Ltd.	A22
English Steel Tool Corpn., Ltd.	—
Exors. of James Mills, Ltd.	A6
Firth, Thos., & Brown, John, Ltd.	A32
Flame Hardeners, Ltd.	A90
Fletcher Miller, Ltd.	A94
Flexello Castors & Wheels, Ltd.	—
Ford Motor Co. Ltd.	A89
G.W.B. Furnaces, Ltd.	—
Garner, Geo., & Sons, Ltd.	A21
Gas Council, The	—
Gear Grinding Co. Ltd.	—
General Electric Co. Ltd.	A81
Gledhill-Brook Time Recorders, Ltd.	A94
Goulder, J., & Sons, Ltd.	—
Guest, Keen & Nettlefolds (Midlands), Ltd.	—
Harvey, G. A., Co. (London), Ltd.	—
Heenan & Froude, Ltd.	A76
Herbert, Alfred, Ltd.	A83
Heston (Aircraft & Associated Engineers), Ltd.	A88
Hey Engineering Co. Ltd.	A82
Honeywell Controls Ltd. (Micro Switch Division)	—
Hordern, Mason & Edwards, Ltd.	—
Hüller, Karl, Ltd.	—
Humphris & Sons, Ltd.	—
Hymatic Engineering Co. Ltd., The	—
Ilford, Ltd.	A24
Ingersoll-Rand Co. Ltd.	A18
Ingham, Robert, Clark & Co.	A49
International Computers and Tabulators, Ltd.	—
Isopad, Ltd.	—
Jacobs Manufacturing Co. Ltd., The	A50
Johansson, C. E., Ltd.	—
Jones,, A. A., & Shipman, Ltd.	A39
Jones, E. H. (Machine Tools), Ltd.	A85
Kane, Douglas, Sealants, Ltd.	—
Kearns, H. W., & Co. Ltd.	A72
King, Geo. W., Ltd.	A73
Kitchen & Wade, Ltd.	A42
Landis Lund, Ltd.	A5
Lang, John, & Sons, Ltd.	—
Ley's Malleable Castings Co. Ltd.	—
Lincoln Electric Co. Ltd., The	—
Lloyd, Richard, Ltd.	—
Lockheed Hydraulic Brake Co. Ltd.	—
Lockheed Precision Products, Ltd.	—
Londex, Ltd.	A84
Macready's Metal Co. Ltd.	A46
Markland Scowcroft, Ltd.	A15
Marsden & Shiers, Ltd.	A94
Maxam Power, Ltd.	—
Measurement Ltd.	—
Metalock (Britain), Ltd.	—
Mobil Oil Co. Ltd.	A52
Morris, B. O., Ltd.	A67
National Industrial Fuel Efficiency Service	—
Neill, James, & Co. (Sheffield), Ltd.	—
Newall, A. P., & Co. Ltd.	—
Newall Engineering Co. Ltd.	—
Newall Group Sales, Ltd.	A53
Newton Chambers & Co. Ltd.	—
Norgren, C. A., Ltd.	—
Norwood Steel Equipment, Ltd.	A79
Optical Measuring Tools, Ltd.	—
Ormerod Shapers, Ltd.	—
Osborn, Samuel, & Co. Ltd.	—
Ottermill Switchgear, Ltd.	A88
Park Gate Iron & Steel Co. Ltd.	—
Parkinson, J., & Son (Shipley), Ltd.	A26
Payne Products International, Ltd.	—
Peak Engineering Co. Ltd.	—
Pearson Panke, Ltd.	—
Pels, Henry & Co. Ltd.	A13
Pollard Ball & Roller Bearing Co. Ltd.	A25
Powell & Co.	—
Power Petroleum Co. Ltd.	—
Precision Grinding, Ltd.	—
Press Equipment, Ltd.	—
Protolite, Ltd.	A36
Pryor, Edward, & Son, Ltd.	A92
Pultra, Ltd.	—
Pye, Ltd. (Process Heating Division)	A47
Renault Machine Tools (U.K.), Ltd.	—
Ratcliffe, F. S. (Rochdale), Ltd.	A90
Reavell & Co. Ltd.	—
Robertson, W. H. A., & Co. Ltd.	A11
Rockwell Machine Tool Co. Ltd.	A31, A92
Rhodes, Joseph, & Sons, Ltd.	A86
Rowen-Arc	A43
Rowland, F. E., & Co. Ltd.	—
Rubert & Co. Ltd.	—
Rubery, Owen Co. Ltd.	—
Russell, S., & Sons, Ltd.	A90
Ryder, Thos., & Son, Ltd.	—
Salter, Geo., & Co. Ltd.	A65
Schrader's, A., Son	—
Selson Machine Tool Co. Ltd.	—
Sharples Centifuges Ltd.	—
Sheffield Twist Drill & Steel Co. Ltd.	—
Shell-Mex & B.P., Ltd.	A54, A55
Smart & Brown (Machine Tools), Ltd.	A91
Snow & Co. Ltd.	—
Speed Tools, Ltd.	—
Standard Piston Ring & Engineering Co. Ltd.	A82
Stein Atkinson Vickers Hydraulics, Ltd.	A3
Sunbeam Anti-Corrosives, Ltd.	—
Super Oil Seals & Gaskets, Ltd.	—
Swift, Geo., & Sons, Ltd.	—
Sykes Machine Tool Co. Ltd., The	A77
Sykes, W. E., Ltd.	—
Talbot Tool Co. Ltd., The	*Inside Back Cover*
Teddington Industrial Equipment Ltd.	—
Telehoist, Ltd.	—
Terry, Herbert, & Sons, Ltd.	—
Tilghman's, Ltd.	—
Town, Frederick, & Sons, Ltd.	A62
Tufnol Ltd.	—
Uni-Tubes Ltd.	—
United Dominions Trust (Commercial), Ltd.	A51
Universal Tools, Ltd.	—
Vacu-Blast, Ltd.	A80
Van Moppes, L. M., & Sons (Diamond Tools), Ltd.	A78
Vaughan Associates, Ltd.	A61
Vaughan, Edgar, & Co. Ltd.	—
Vickers-Armstrongs (Engineers), Ltd.	A33
Vulcascot (Gt. Britain), Ltd.	—
Wadkin, Ltd.	A84
Wakefield-Dick Industrial Oils, Ltd.	—
Ward, H. W., & Co. Ltd.	A27
Ward, Thos. W., Ltd.	—
Wayne-Kerr Laboratories, Ltd.	—
Weatherley Oilgear, Ltd.	A44
Webster & Bennett, Ltd.	A20
Welsh Metal Industries, Ltd.	—
West, Allen, & Co. Ltd.	—
Whiffen & Sons, Ltd.	A38
Wickman, Ltd.	A48
Wiggin, Henry, & Co. Ltd.	—
Wild-Barfield Electrical Furnaces, Ltd.	—
Wilkins & Mitchell, Ltd.	A17
Woodhouse & Mitchell	—
Zeiss, Carl, Jena	—
Zwicky, Ltd.	A23

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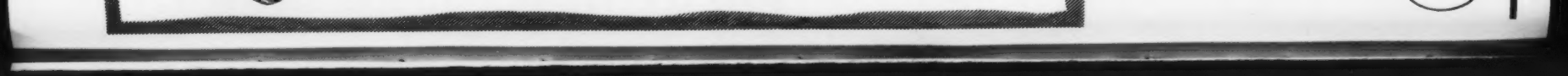
Page
A25
A36
A92
A47
A90
A11
A92
A86
A43
A90
A65
A55
A91
A82
A3
A77
Cover
A62
A51
A80
A78
A61
A33
A84
A27
A44
A20
A38
A48
A17
A23



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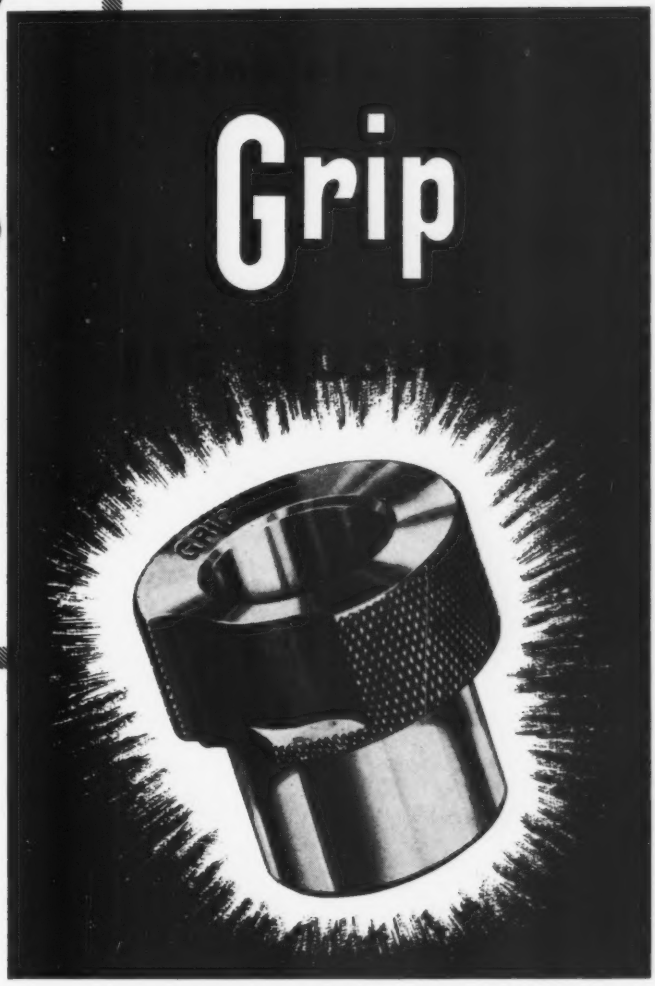

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